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OBSERVATIONS ON THE INHERITANCE OF SEX IN SCIARA OCELLARIS
(DIPTERA)

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This paper deals with the problem of the inheritance of sex in the fungus fly *Sciara ocellaris*, Comstock. It has been previously shown by Metz and his associates (see Metz, 1929, for a summary of the work) that in *S. coprophila* the females regularly yield "unisexual progenies." That is, the offspring of one female are all or nearly all of one sex, the term "progeny" being used by Metz and in this paper to designate the offspring of a single female. In another species, *S. reynoldsi*, the females regularly yield "bisexual progenies." In this case among the offspring of one female there may be both males and females in various ratios, usually not 1:1. In *S. ocellaris* it was found by them that some females yield unisexual and some bisexual progenies.

In Sciara the sex of the individual is not determined by the kinds of chromosomes in the zygote but by the results of the chromosome elimination which occurs during the early development of the embryo. Cytological and genetic investigations on Sciara by Metz and his co-workers have shown that there are two X chromosomes in the germ line of each sex. Oogenesis is typical and each ovum has one X chromosome. Spermatogenesis is atypical. In the first spermatocyte division a unipolar spindle is formed and the chromosomes of maternal origin go to the pole while those of paternal origin go away from it and are budded off and disintegrate. In the second spermatocyte division, which is bipolar, both halves of the X chromosome go together, precociously, to one pole. The chromosomes which go to the other pole are budded off and lost. The resulting cell is haploid except for two X chromosomes, which are genetically equal, the products of the division of one. Thus all male gametes contain two X chromosomes and all the gametes of any individual male are genetically alike, containing the maternal complement of genes (Metz 1926, 1928, 1929). The fertilized egg is then trisomic, containing three X chromosomes.

The significance of three X chromosomes in the fertilized egg is not clear, for during cleavage the number is reduced to one in the soma of the male, to two in the soma of the female, and to two in the germ-line of both (DuBois 1933, Berry 1939). The eliminated chromosomes are normally paternal in origin. At least one of the genetically-equal paternal X chromosomes is normally eliminated from all cells before the embryo develops. The sex of the individual is determined by the number of X chromosomes remaining in the soma after elimination has taken place. If one remains the individual becomes a male, if two, a female.

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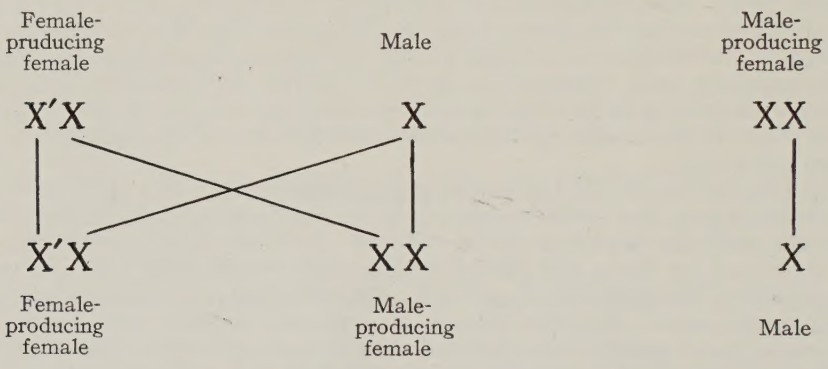
A cytological difference between *S. coprophila* and *S. ocellaris* is the presence of "limited chromosomes" in *S. coprophila* and their absence in *S. ocellaris*. In *S. coprophila* these are limited to the germ-line of both sexes. It has been shown that the limited chromosomes are not sex-determiners (Metz and Ullian, 1929) and they will not be considered further here. Otherwise the two species seem to be alike cytologically.

The X chromosomes have been found to be of two kinds in *S. coprophila* (Metz and Schmuck, 1929, Metz and Smith, 1931) and have been designated X and X' (X prime). The X' chromosome differs from the X in possessing a dominant "prime factor," which is not necessarily a single gene but may be two or more apparently completely linked genes or a segment of the chromosome. No crossing-over has been observed between the X and X'. It has been demonstrated that females carrying the X' chromosome are female-producers. That is, they yield progenies which are entirely of females or nearly so. Females homozygous for the X chromosomes are male-producers. Males from male progenies do not have the X' chromosome. Hence female-producers mated to males of male progenies are expected to yield female-producing and male-producing daughters in a ratio essentially 1:1. The X and X' chromosomes have both been genetically marked. Four recessives have been found on the X and a dominant on the X'.

This may be more easily seen with the aid of a diagram (Fig. 1). The male may be represented by X since it effectively transmits only one.



A female-producing female is heterozygous for the prime factor, and so may be considered digametic. A male-producing female does not have this factor on either of its X chromosomes and so is monogametic. As previously explained, the males get their somatic X from the female parent. Although one of the two X chromosomes in the germ-line of the male is paternal, it is not transmitted.

Although the presence or absence of a prime factor in the female parent determines the sex of the progeny as a whole it does not determine the sex of the individual offspring, for "exceptional" individuals occur. That is, a few females are found in some of the male progenies and a few males occur in some of the female progenies. As expected, the exceptional females are male-producers for they are without the prime factor. It will be presently shown that this condition does not exist in *S. ocellaris*. Here both unisexual and bisexual progenies occur. No prime factor is found and the evidence points toward the conclusion that a number of sex-determining factors affecting the sex ratio are present, some pulling in one direction and some in the other.

MATERIALS

The original flies obtained for this work came from cultures 1688 and 1692 of the laboratory of C. W. Metz. They are from a stock (1255) originally secured

by J. P. Reynolds in Alabama. The yellow flies used in the crosses were from the mutant strain discovered by E. G. Lawrence in this laboratory. The genes for yellow body and curled wing are sex-linked recessives and both known to be consistent in expression.

EXPERIMENTAL RESULTS

Tests for the prime factor.

As previously explained, females of *S. coprophila* typically produce unisexual progenies, female or male, depending on whether the female parent is genetically X'X or XX. No crossing over has been found to occur between the X' and X chromosomes and only about .5% has been observed between the two genes on the X. The X' and X chromosomes are both genetically marked in this species. Hundreds of tests carried on over a period of years and all giving consistent results (Metz and Schmuck, 1929a, Metz and Smith, 1931) have shown that females carrying the X' chromosomes are female-producers and those homozygous for the X are male-producers.

TABLE I

SETS OF SIBS WHICH PRODUCED MALE AND FEMALE PROGENIES IN A RATIO HIGHLY SIGNIFICANT IN THEIR VARIANCE FROM A 1:1 RATIO. TEN SETS OUT OF 54 IN THE UNISEXUAL STRAIN AND EIGHT OUT OF 25 IN THE BISEXUAL

	Female Progenies	Male Progenies	Probability
Unisexual strain	9	26	.0092
	0	8	.0078
	13	2	.0074
	13	2	.0074
	35	14	.0040
	9	0	.0040
	0	9	.0040
	42	18	.0024
	1	13	.0020
	45	5	.0000
Bisexual Strain	19	5	.0064
	2	14	.0040
	13	1	.0020
	10	32	.0008
	31	6	.0000
	1	21	.0000
	0	15	.0000
	39	0	.0000

When similar tests are applied to *S. ocellaris* the results obtained are different. There are two sex-linked genes in this species, yellow and curled, both recessive. Recombination between them is about 13%. The yellow gene has been used in the present work.

Yellow females may be either female-producers or male-producers. In this they differ from the females of *S. coprophila*, where a genetic marker designates either an X or X' chromosomes and therefore either a male-producer or a female-producer. Recessives on the X' of *S. coprophila* would not ordinarily show, as females are not X'X'. It appears, therefore, that if a prime factor exists in *S. ocellaris* it is not completely linked with the yellow locus.

On the basis of conditions found in *S. coprophila*, as already outlined, it would be expected that in *S. ocellaris* half the females in female progenies would be female producers (X'X) and the other half male-producers (XX). This assumes

that the male parents are derived from male progenies and hence carry only X and not X'. Exceptional males from female progenies are not used because of the possibility of some of them carrying an X' chromosome. This expectation is not realized in *S. ocellaris*. Among sisters in this species the ratio of female-producers to male-producers is frequently far from 1:1. Out of 54 sets of sisters from unisexual stock in which eight or more sisters were tested in each set, the divergence from a 1:1 ratio was highly significant in ten sets. That is, in these cases the probability of getting the ratio obtained by chance when a 1:1 ratio was expected was less than one chance in a hundred. Out of a sample of 54 it would not be very uncommon to get by chance a case which would by this definition be highly significant, but to get ten out of 54 is not within the realm of probability. Similarly in 25 such sets in bisexual stock there were eight cases in which the divergence from a 1:1 ratio was highly significant. The counts and respective probabilities are given in Table I. It is to be noted from the table that in some cases the probability is far below .01 and that in some others the size of the sample is rather small and might have produced a still more significant variation from the 1:1 ratio had the sample been larger. These sets of sisters were not among those tested for the prime factor with genetic markers nor were they from the female-producing line mentioned later.

TABLE II

FEMALE-PRODUCERS AND MALE-PRODUCERS IN PROGENIES WHERE AN EFFORT WAS MADE TO MATE ALL SISTERS

Females in Progeny	Female-Producers	Male-Producers	Probability on Basis of 1:1	Percent of Females Giving Progenies
77	25	28	.7948	69
82	34	30	.7082	68
106	33	38	.6350	67
56	26	20	.4616	82
99	47	38	.3858	86
60	30	20	.2024	83
88	47	31	.0888	89
69	42	18	.0024	87
71	45	5	.0000	70

In bisexual progenies there is a tendency for males to hatch earlier than females. If, similarly, there is a tendency for one type of female to hatch before the other, a skew ratio might be obtained when none in fact existed provided females hatching first were mated and those hatching later discarded. This, however, appears not to be the case for the following reasons: (1) As will be seen in Table I, among the unisexual lines which gave highly significant skew ratios six were predominantly female and four predominantly male, and in the bisexual line four were female and four male. If there had been an unintentional selection of females hatching early or late the skew ratios would be expected to be predominantly all of the same sex. (2) When the date of hatching of each female was recorded the results indicated no tendency for one type of females to hatch earlier than the other. (3) When all the females of a progeny were mated and a skew ratio obtained there could be no selection except selective mortality or sterility. Table II shows results where an effort was made to obtain offspring from each female in a progeny, with better than 60% yield. In two progenies out of nine a highly significant skew ratio occurred.

From the evidence presented it is concluded that ratios differing from 1:1 as to female-producers and male-producers do occur in female progenies in this species.

Test for the prime factor with genetic markers.

The recessive sex-linked gene yellow in *S. ocellaris* may be used to test directly whether there is a prime factor on an X chromosome determining the sex of progeny as there is in *S. coprophila*.

If a female progeny is obtained from a homozygous wild-type female by a yellow male, the female offspring are wild-type in color and heterozygous for yellow. If a prime factor operates as in *S. coprophila*, it should be derived in this case from the wild-type mother. If the F_1 females are mated to yellow males some of their daughters will be wild-type and some yellow, and except for cases involving crossing-over the wild-type daughters should be female-producers and the yellow ones male-producers. This is represented diagrammatically in Fig. 2 below, where + stands for wild-type and y for yellow. A male is represented by only one gene as a male effectively transmits only one X chromosome. Fig. 3 shows the crosses which would yield the opposite condition, in which wild-type daughters should be male-producers and yellow daughters female-producers.

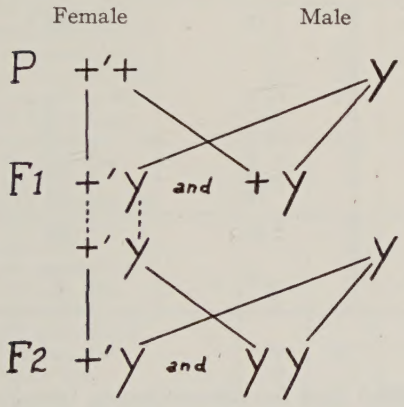


Fig. 2

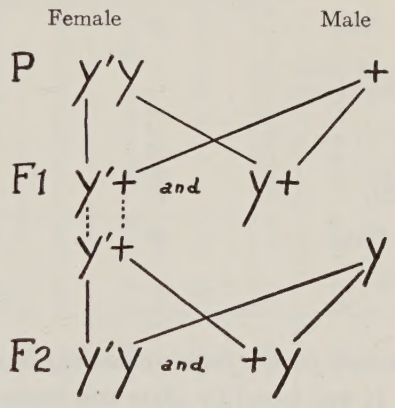


Fig. 3

Crosses of the first type yielded from three progenies, 73 wild-type F_2 females, all expected to be female-producers. Actually, 38 proved to be female-producers and 35 to be male-producers. Eighty-two of their yellow sisters, expected to be male-producers, included instead, 47 female-producers and 35 male-producers. Neither 38 to 35 nor 47 to 35 is significantly different from a 1:1 ratio, and from these figures to postulate a prime factor one would need to assume 50% crossing over or non-linkage.

In the second cross 173 females, of which 90 were wild-type and 83 yellow, were secured from five progenies. They produced progenies as follows: Of the 90 wild-type females expected to be male-producers, 60 were female-producers and 30 male-producers, which is a highly significant variation from the 1:1 ratio. Of their 83 yellow sisters, which were expected to be female-producers, 41 were female-producers and 42 were male-producers, a 1:1 ratio. Yellow females of another progeny, of which no wild-type sibs were saved, turned out to be 3 female-producers and 17 male-producers. This is a highly significant variation from the 1:1 ratio and in the direction opposite from the expected.

These data make it clear that there is no prime factor on the X chromosome acting as a unit as in *S. coprophila* and linked either completely or incompletely with yellow, nor is there a unit autosomal prime factor showing independent assortment with yellow. These results are given in Table III.

TABLE III

SHOWING THAT A "PRIME FACTOR" OPERATING AS IN *S. coprophila* IS NOT ACTING IN THIS SPECIES. IF IT WERE, IN THE FIRST CROSS THE WILD-TYPE SIBS WOULD ALL BE FEMALE-PRODUCERS AND THE YELLOW ONES ALL MALE-PRODUCERS, WHILE IN THE SECOND CROSS THE RESULT WOULD BE JUST THE OPPOSITE

Parent Culture	WILD-TYPE SISTERS		YELLOW SISTERS	
	Female-Producers	Male-Producers	Female-Producers	Male-Producers
First cross (figure one)				
AKI	6	6	17	4
BDZ	19	17	11	11
BEA	13	12	19	20
Total	38	35	47	35
Second cross (figure two)				
FY	4	2	7	2
HX	4	5	3	5
HY	7	0	3	7
AUB	20	10	9	10
AUD	25	13	19	18
Total	60	30	41	42
GCM			3	17

Evidence from a female-producing line.

It was found by Metz and Schmuck (1929b) that female-producing females of *S. coprophila* could have X' sons, which when mated to female-producing females would yield some X'X' females. The daughters of such females are all female-producers and their exceptional sons carry and transmit the X' chromosome. By continually mating females to their exceptional brothers, only female-producers should be obtained, no matter how many generations this be carried on.

A female-producing line of *S. ocellaris* was obtained from a female caught in one of the government greenhouses in Washington, D. C. For three inbred generations all females tested were female-producers. As there were 129 of these, with an average of 75 offspring per female, the results cannot possibly be attributed to chance.

Lest a misunderstanding arise it should be explained that in the inbred female-producing line not all females tested were mated to their brothers, as there were not sufficient exceptional males to do this. The exceptional males were mated to as many of their sisters as possible to produce inbred lines and the rest of the females were mated to other males to ascertain whether or not they were female-producers. It has been shown by Metz that in *S. coprophila* the male parent does not affect the sex of the immediate progeny. It may be noted that if there were any effect it would probably tend to prevent rather than bring about the result here obtained, since the other males were not from female-producing lines.

Thus if there were a single prime factor operating, all future inbreeding should yield only female progenies. This was not the case. By selecting females from

progenies in which there were fewer exceptional males the female strain was maintained, while at the same time selecting females from progenies in which there were more exceptional males a large proportion of male progenies was obtained after a few generations. These results are summarized in Table IV. Apparently male-producers were obtained by chance combinations of factors for male-produc-

TABLE IV

RESULTS OF SELECTION IN A MALE DIRECTION IN A FEMALE-PRODUCING LINE, BEGINNING AT THE SEVENTH GENERATION. EACH NUMBER REPRESENTS THAT MANY PROGENIES. THEY ARE DIVIDED INTO GROUPS CORRESPONDING TO THE PER CENT OF THE MINORITY SEX IN THE PROGENY

	FEMALE PROGENIES					MALE PROGENIES				
	0–9	10–19	20–29	30–39	40–49	40–49	30–39	20–29	10–19	9–0
First generation	1	0	0	0	0	0	0	0	0	0
Second generation	4	6	4	3	4	3	2	4	4	2
Third generation	12	25	17	13	7	10	3	2	3	0
Fourth generation	46	10	2	0	0	0	0	0	0	0
Fifth generation	14	10	3	0	0	0	0	0	0	0
Sixth generation	38	5	0	0	0	0	0	0	0	0
Seventh generation	55	24	12	5	2	1	1	0	0	0
Female line	9	2	1	1	0	0	0	0	0	0
Male line	10	5	2	0	1	0	1	0	0	0
Eighth generation										
Female line	8	3	0	0	0	0	0	0	0	0
Male line	1	4	2	0	0	6	2	3	4	4
Ninth generation										
Female line	28	6	0	0	1	0	0	0	0	0
Male line	7	1	2	1	4	2	0	2	2	7
Tenth generation										
Female line	46	22	6	1	2	0	0	0	0	0
Male line	0	1	1	1	1	8	6	8	7	12
Three sets tested for the prime factor. See text and figure 4.										
Wild-type females	1	3	8	7	5	4	1	0	0	7
	1	1	6	8	5	1	3	0	0	7
	0	3	4	7	3	1	0	1	0	2
Total for wild-type females	2	7	18	22	13	6	4	1	0	16
Yellow females	1	1	0	2	1	3	0	2	0	22
	0	0	3	2	2	2	1	0	0	21
	0	1	0	2	2	0	0	0	0	6
Total for yellow females	1	2	3	6	5	5	1	2	0	49
Total for wild-type and yellow females	3	9	21	28	18	11	5	3	0	65

tion or lack of female-production. It should be possible to obtain a stable female-producing strain by continued selection until flies are obtained which are homozygous for the factors which make for female-production.

At the same time a male-producing line was obtained from the same original female from which the female-producing line mentioned above was obtained. This line was essentially bisexual and so differed from a male-producing line in *S. coprophila*, which could only be obtained by mating exceptional females (which

are without the prime factor) to their brothers. Out of 105 females tested during six generations, all but three produced more males than females. Of these three, two produced only one more female than males and the other produced two more females than males.

The female-producing females were also outcrossed to yellow so as to mark the X chromosome. If a single prime factor were located on this chromosome without crossing over, the result should be as follows (Fig. 4) when the first generation females are backcrossed to yellow.

The wild-type females are all expected to be female-producers and the yellow females are expected to be male-producers. The results may be seen in Table IV, a number of the progenies were bisexual, especially from the wild-type females.

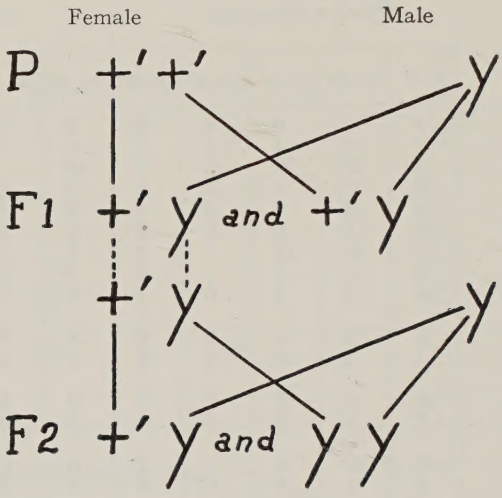


Fig. 4

The line dividing progenies between the categories predominantly male and predominantly female appears to divide the progenies arbitrarily and the natural division falls between the unisexual male progenies on the one hand and all the others. This is even more striking than the table indicates, for of the 65 unisexual male progenies two had one exceptional female each and all the others, with an average of 102 flies each, were all males with no exceptional females.

If the unisexual male progenies are considered as the expected male progenies and all the others as the expected female progenies, the results for the wild-type females are, 75 non-crossovers and 16 crossovers, and for the yellow females, 49 non-crossovers and 25 crossovers. If these numbers are set in a two-by-two table it is found that chi-square is 5.37, which is significant, though not highly significant. The results, therefore, do not preclude the possibility that a factor linked with the locus of yellow and crossing over with it is operating here and determining a bisexual and unisexual condition.

Bisexual females from the strain just considered seem to have three X chromosomes in their germ-line instead of two, a condition observed by Reynolds (1938) in a bisexual strain of *S. coprophila*. He found that some of the ova get two X chromosomes and some get one, in oogenesis. The former become females and the latter males. This does not involve the X' chromosome and in returning to the normal condition the females all were male-producers.

The evidence that the three-X condition existed in this line is as follows: (1) Wild-type and yellow females were produced in some crosses between wild-type females and wild-type males. Ordinarily yellow females are never found in progenies resulting from such crosses because a wild-type male transmits only the X chromosome bearing the wild-type gene. This is so because in the developing male the two X chromosomes of paternal origin in the trisomic zygote are elimnated in the somatic tissue and one is eliminated in the germ-line. Later, when germ cells are formed, all the chromosomes of paternal origin are lost in the first

TABLE V

SHOWING THE DISPERSION ON A MALENESS-FEMALENESS SCALE OF THE PROGENIES OF FOUR GROUPS OF CLOSELY RELATED FEMALES. IT IS TO BE NOTICED THAT THE PATTERN IS SIMILAR FOR FEMALE-PRODUCERS AND SIMILAR FOR MALE-PRODUCERS IN EACH GROUP, REGARDLESS OF THE SEX-LINKED PHENOTYPE, BUT DIFFERENT WHEN FEMALE-PRODUCERS ARE COMPARED WITH MALE-PRODUCERS. THE NUMBERS STAND FOR PROGENIES, NOT INDIVIDUAL FLIES

	INDIVIDUALS OF MINORITY SEX PER 100 OF MAJORITY SEX										
	0	1–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99
I. Wild-type female-producers	0	2	3	6	15	9	12	4	5	6	0
Yellow female-producers	0	2	1	1	2	2	2	3	1	1	2
Wild-type male-producers	16	0	0	0	1	0	3	2	1	3	1
Yellow male-producers	47	2	0	0	2	0	0	1	2	3	0
II. Wild-type female-producers	0	9	6	2	2	0	0	0	0	0	1
Yellow female-producers	0	4	2	2	1	0	0	0	0	0	1
Wild-type male-producers	16	1	0	0	0	0	0	0	0	0	1
Yellow male-producers	10	1	0	0	0	0	0	0	0	0	0
III. Wild-type female-producers	5	8	0	0	0	0	0	0	0	0	0
Yellow female-producers	6	13	0	0	0	1	0	0	0	0	0
Wild-type male-producers	0	3	0	2	6	4	1	0	1	0	0
Yellow male-producers	1	6	6	4	2	2	0	0	0	0	0
IV. Wild-type female-producers	4	8	2	1	1	1	1	0	0	0	0
Yellow female-producers	4	11	0	1	0	1	1	0	0	1	0
Wild-type male-producers	12	2	1	1	0	0	0	0	0	0	0
Yellow male-producers	9	3	0	0	0	0	0	0	0	0	0

spermatocyte division, as previously explained. (2) Yellow females from the cross just described mated to yellow males yielded wild-type and yellow males and females. Ordinarily in crosses of yellow by yellow the offspring are all yellow, as any fly which could transmit the wild-type gene would manifest it phenotypically. (3) That such females have in their germ-line three X chromosomes rather than being heterozygous and having two is further indicated by the ratio of the offspring. Heterozygous females mated to yellow males produce wild-type and yellow offspring in a ratio close to 1:1. But if a female has two X chromosomes bearing yellow and one bearing wild-type, it is to be expected that twice as many female offspring will be wild-type as yellow and twice as many male offspring will be yellow as wild-type. In general this proportion was realized in these cases but

sometimes the ratio was still farther from 1:1 than expected, indicating a tendency for the yellow chromosomes to segregate more frequently than would be expected by chance.

It may be seen from the entries in Table IV under the sets tested for the prime factor, and still more clearly in Table V, that the distribution pattern is similar for the wild-type and yellow female-producers and similar for the wild-type and

TABLE VI

THE PROGENIES OF SISTER FLIES, GROUPED TO SHOW THEIR DISTRIBUTION ON A MALENESS-FEMALENESS SCALE. THE NUMBERS REPRESENT PROGENIES, NOT INDIVIDUALS. THEY ARE ARRANGED IN COLUMNS ACCORDING TO THE PER CENT OF THE MINORITY SEX IN EACH PROGENY. EACH ROW REPRESENTS A SET OF PROGENIES FROM SISTERS, AND THE SETS ARE ARRANGED IN ORDER, BEGINNING WITH THOSE HAVING THE MOST FEMALE PROGENIES

PERCENT FEMALES					PERCENT MALES					TOTALS	
0-9	10-19	20-29	30-39	40-49	40-49	30-39	20-29	10-19	0-9	♀ Progenies	♂ Progenies
11	13	9	2	4	0	0	0	0	0	39	0
5	6	5	7	8	3	2	0	1	0	31	6
0	6	1	4	8	1	2	1	0	1	19	5
1	1	2	4	3	3	1	0	1	0	11	5
3	4	3	1	2	5	0	0	1	0	13	6
0	1	5	6	5	3	4	1	0	0	16	8
0	3	7	8	7	6	5	2	0	0	25	13
0	0	4	5	3	4	0	4	0	0	12	8
2	2	3	2	3	5	2	1	2	0	12	10
0	0	1	6	0	1	1	3	1	0	7	6
0	0	4	6	2	4	4	2	1	0	12	11
0	3	0	0	4	2	3	1	2	0	7	8
1	1	4	7	7	6	7	6	4	1	20	24
0	1	1	2	5	4	3	4	3	0	9	14
0	1	2	1	1	3	1	2	4	2	5	12
0	1	0	2	2	5	5	1	2	0	5	13
0	0	2	5	3	10	4	9	6	3	10	32
0	0	0	3	0	0	1	3	5	1	3	10
0	0	0	1	1	1	0	7	6	0	2	14
0	0	0	0	1	0	2	3	6	2	1	13
0	0	0	1	0	4	8	7	1	1	1	21
0	0	0	0	0	2	3	4	4	2	0	15
Totals of the three groups respectively.											
19	33	33	38	41	26	13	9	2	1	166	51
3	6	12	21	16	18	17	13	11	1	58	59
0	3	5	15	13	29	27	40	37	11	36	144

yellow male-producers, but is different in the female-producers as compared with the male-producers. Each number represents that many progenies and in Table V they are arranged in columns by the number of individuals of the minority sex in each progeny per hundred of the majority sex. The first four rows are the same as the totals for the three sets tested for the prime factor entered in Table IV. This indicates some factor independent of the X chromosome but associated with the determination of sex of progeny which determines, within certain limits, whether the progeny is unisexual or bisexual.

It will be seen in Table IV under the three sets tested for the prime factor and the totals given there that the distribution is bimodal. In unisexual lines the distribution is strictly bimodal, with the female progenies at one end of the distribution and the male progenies at the other. In some bisexual sets the distribution of the progenies of sisters has a single mode. The number of progenies with more females and the number with more males frequently are not in a 1:1 ratio. This is shown in Table VI, where twenty-two closely related sets of progenies are tabulated. It will be seen that the progenies of sisters tend to group together when arranged on a scale of femaleness and maleness and when one sex predominates there is a tendency for more progenies of that sex to be unisexual than for progenies of the other sex.

Some crosses have been made between unisexual and bisexual lines and the first generation females tested to find out what kind of progenies they yield, but much remains to be done. As may be seen in Table VI, there are frequently some unisexual progenies in a bisexual line and the distribution of the progenies forms a curve with a mode somewhere near the center and with the ends tapering off. Females from unisexual progenies derived from a bisexual line may yield bisexual progenies, though a continued selection for unisexual progenies would probably after a time yield a stable unisexual line.

TABLE VII

THE RESULTS OF SOME CROSSES BETWEEN UNISEXUAL AND BISEXUAL STRAINS

Parentage of First Generation	Number of First Gen. ♀ ♀ Tested	Nature of Second Gen. Progenies	Exceptionals per 100 of Others
♀ unisexual, ♂ unisexual..	86	Unisexual.....	1.2
♀ unisexual, ♂ bisexual...	69	Unisexual.....	1.3
♀ unisexual, ♂ bisexual...	53	Some unisexual, some bisexual.....	15.7
♀ unisexual, ♂ bisexual...	91	Bisexual.....	58.3
♀ bisexual, ♂ unisexual...	44	Some unisexual, some bisexual.....	9.5
♀ bisexual, ♂ bisexual....	102	Some unisexual, some bisexual.....	32.0

In Table VII is presented the results of several crosses. The unisexual progenies mentioned here are all from stable unisexual lines. The variation in results, the fact that unisexual progenies from a bisexual source are not stable, and the grouping of the progenies of sisters about a mode which is not the same for different sets of sisters, indicate the presence of more than one factor and its allele determining the sex ratio of the progenies.

DISCUSSION

There are three different problems in the determination of sex in Sciara: (1) the determination of the sex of the individual, (2) the determination of the sex of progenies, and (3) the determination of the sex of groups of closely related progenies, such as the progenies of sisters.

The determination of the sex of individuals by the elimination of chromosomes has already been discussed at length. Gynanders are not uncommon in *S. ocellaris*. The division is usually roughly with the longitudinal axis of the body. When the female parts are wild type and the male parts are yellow they may be readily distinguished and much variation in pattern is observed among individuals.

To discover whether a sex-linked "prime factor" similar to that in *S. coprophila* occurs in *S. ocellaris*, three types of crosses were made, each of which would reveal

the presence of such a factor. The results expected on the assumption of this factor were not realized in any of the crosses. In some cases the number of female-producers was essentially the same as the number of male-producers among sisters which were all expected to be male-producers, and vice versa. In some cases skew ratios were obtained, which occurred in the direction opposite to the expected as well as in the expected.

In keeping stock cultures of *S. ocellaris* one of the difficulties encountered is that a line may at any time "go male" or "go female" so that it becomes difficult to provide for the next generation. If a single factor were operating to determine the sex of progeny, male and female progenies should be produced each generation in essentially equal numbers. Also a female-producing line would remain such as long as inbred with exceptional males instead of becoming male after a few generations of selection.

Skew ratios sometimes occur in the inheritance of the X chromosome from heterozygous females, but this cannot be related to the skew ratios of sex of progeny, for it is far less frequent and a much larger sized sample is necessary to detect it.

There may be a marked similarity in the distribution on a maleness-femaleness scale among progenies of the female-producers of both phenotypes and among the male-producers of both phenotypes, while no such similarity is found when the female-producers are compared with the male-producers (Table V). From this it appears that a factor or factors determining the distribution of progenies is associated with the determination of sex of progeny, and seems to be autosomal since it is independent of the sex-linked phenotypes.

In other cases sisters of one phenotype produced male and female progenies in a ratio significantly skew while their sisters yielded male and female progenies in a ratio of 1:1 (Table III, AKI, AUB, AUD). In each case the size of the sample was not great enough to show the two sets of data significantly different from each other in a two-by-two table. If the difference is real, its cause seems to be a sex-linked factor.

Where the sex of progenies is distributed along a scale from unisexual to bisexual, the dividing point between these two groups becomes arbitrary. In such cases progenies were called bisexual if there were ten or more individuals of the minority sex per hundred of the majority sex, for in unisexual strains the ratio of exceptionals does not ordinarily exceed this.

The age of the female parent appears to make no difference in the sex of progeny, as no significant difference was observed among progenies of the second generation from females mated when less than eight hours old and females mated when over one hundred twenty-three hours old. These lines were closely related, as the females tested were sisters and they were mated to brothers.

External environment also seems to be eliminated as a factor in these results. No tests were made to ascertain this, but cultures were kept together on the same table and frequently some groups of sisters would be yielding bisexual progenies at the same time that others were yielding unisexual progenies, and some groups of progenies would be predominantly male at the same time that others were predominantly female.

From the facts obtained in the present study it is concluded that sex of progeny in *S. ocellaris* is determined by a number of factors, predominantly autosomal, though some may be sex-linked. It is certain that a determiner acting as a unit like the prime factor in *S. coprophila* does not exist in *S. ocellaris*, at least in the strains thus far studied. To ascertain more definitely where these determiners are it is desirable or necessary to have a number of autosomal markers and viable deletions.

Since no crossing over has been observed in *S. coprophila* between the X and X' chromosomes, though there are two markers on each, there is a possibility that the prime factor actually is multiple in this species also and spread over the X' chromosome. A transition from one species to the other, accompanied by translocations, could cause such a multiple factor on one chromosome to become scattered on other chromosomes. On this hypothesis, *S. coprophila* would be the older species. In the contrary case, a concentration of factors on one chromosome by translocations from others would be implied, which seems less likely.

SUMMARY

1. *Sciara ocellaris* produces both unisexual and bisexual progenies, in contrast to *S. coprophila*, which typically produces only unisexual progenies. In *S. ocellaris* some unisexual strains are stable. Apparently all bisexual strains are unstable, for if a number of sisters are tested some yield unisexual progenies and some bisexual. The distinction between these two types of progenies is not always clear, for there may be a complete series from unisexual progenies to those in which males and females are present in a ratio of 1:1. Females of unisexual progenies from a bisexual source may yield bisexual progenies.

2. From the results of three kinds of crosses it is shown that the sex of progeny is not determined by the presence or absence of a single sex-linked "prime factor," as it is in *S. coprophila*. In no case were the results expected on this assumption realized.

3. It is shown that no single autosomal "prime factor" exists in this species. By selecting less strongly female progenies of a female-producing line, male progenies were obtained after several generations, while selecting for the more strongly female progenies continued a female-producing strain. On the assumption of a single autosomal factor, the strain would be homozygous and no amount of selection would affect it.

4. Evidence that a sex-linked factor or factors may be operating is given in that male and female progenies of sisters of one sex-linked phenotype may occur in a skew ratio while the progenies of their sisters of the other phenotype occur in a 1:1 ratio.

5. Also there is evidence of autosomal factors, since the distribution on a maleness-femaleness scale may be strikingly similar for progenies of female-producing and male-producing sisters of both phenotypes, but dissimilar (not mirror-image distributions) when the male-producing and female-producing sisters are compared.

6. Female-producers heterozygous for a single "prime factor" should yield female-producing and male-producing females in essentially equal numbers. However, a number of ratios occur which differ significantly from a 1:1 ratio, and seem to be free of any accidental selection.

7. These results do not appear to have been influenced by external or internal environment.

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Ageing and Degenerative Diseases

Are you growing old and fat, and reading the papers telling of your good friend passing on? While you're reflecting on whether you may be next, why not read this good book on our accumulating knowledge and widespread ignorance of ageing? Thirteen authors contributed their clinical or experimental experience at a symposium on the processes of ageing and diseases of older persons in St. Louis, March 24, 25, 1944.

W. C. Hueper wrote a carefully organized summary of the last fifty years' contributions to the relationships of physical and chemical agents of endogenous and exogenous origin to the histopathological changes of the large and small blood vessels, with interesting side remarks on their regional anatomical localization. Two tables give full data on the etiological factors and the anatomical types of spontaneous and experimental arteriosclerosis. Well documented by American and foreign literature the anoxemic causative mechanisms are considered equally in small animal and human observations, with frequent references to clinical diseases and with implications of their import to future clinical research, prophylaxis and treatment.

Irvig H. Page presented a very readable series of questions and answers on arteriosclerosis and lipid metabolism, terminating in the final query—How can the known factors which predispose to atherosclerosis be controlled? Stimulating to the clinician and inquisitor alike is the conclusion: "First prevention of hyperlipemia, second, prevention of the mechanical strain, and third, prevention of that state of the tissues in the arterial walls which increases the receptivity to plasma lipids or prevention of that state of the blood which leads to abnormal precipitability of its lipids."

William B. Kountz outlined the early trial and error methods in the St. Louis City Infirmary resulting in the conclusion that clinical study of degeneration must focus on the functional ability of the body. His coworkers gave two clinical investigations. One was a study of 212 aged patients to relate age, sex, basal metabolic rate, cardiac decompensation and coronary and peripheral sclerosis to blood cholesterol levels, with the conclusion that there was no relation of blood cholerterol to the degree of atherosclerosis. The other study concluded that with increasing age, there is a gradual lowering of glucose tolerance but not to a degree that could be considered diabetic.

The Pediatrics department presented a case of progeria (premature senility).

Lester R. Dragstedt reported observations suggesting that the factors responsible for the primary deposition of lipids in the intima may be similar to those producing such deposits in the liver. As Lipocaic fat-free alcohol extract of the pancreas) prevents the deposition of fat in the liver.

Edward J. Stieglitz emphasized the factors obstructing diagnosis (tentative opinions): (1) difficulties inherent in the disease, (2) difficulties inherent in the patient, (3) inadequacy of clinical methods, and (4) complexities of diagnoses per se.

Wm. J. Kerr offered a challenge to the adequate therapeutic management now available in obesity, postural defects, pulmonary emphysema and circulatory failure. Wm. MacNider predicted that the research of the future would be increasingly of a biochemical and biophysical order.

John A. Saxton, Jr., reported the experiments of McCay et al. indicating that the life span of rats can be extended 50 per cent by drastic reduction of caloric intake from early life. Also, the incidence of tumors, nephrosis, chronic pneumonia, middle ear disease and gastrointestinal lesions are less. Implications in man are suggested.

Leo Loeb, discussing cancer and the processes of ageing, concluded the necessity of an accumulation of stimuli of a certain kind and range of intensity, acting over a continuous length of time on a given tissue, which has been sensitized by genetic factors specific for each tissue, organ, individual and species. Observations on Mammary carcinoma of mice illustrated the genetic principles.

A final round table discussion made one realize the flux and infancy of our knowledge of ageing, a growing problem of our century.—*Grant O. Graves, M. D.*

Ageing and Degenerative Diseases, Volume XI of the Biological Symposia Series. Jaques Cattell Press, Lancaster, Pa. 1945.

THE CHEMISTRY OF ELEMENTS 93, 94, 95 AND 96 (NEPTUNIUM, PLUTONIUM, AMERICIUM AND CURIUM)

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Four new elements have been added to the list of 92 elements in the last six years. All of these were made artificially; one of them, plutonium (Pu^{239}) has since been discovered in uranium-bearing ore at a concentration of about 1 part in 10^{14}. These elements are known as elements 93, 94, 95 and 96 or as neptunium, (Np), plutonium, (Pu), americium, (Am), and curium, (Cm).

The method of preparation of these elements by means of nuclear transformations together with other facts about them are given in Table I.

Of interest among these isotopes are $_{93}Np^{237}$ and $_{94}Pu^{238}$; these isotopes have long half-lives which make them useful for the determination of many of their chemical properties. Such properties were determined with very minute amounts of these elements by tracer techniques and special micro methods.

Also of interest is $_{94}Pu^{239}$ because of its long half-life and the fact that it captures slow neutrons to fission and hence serve as a useful source of atomic energy. $_{93}Np^{239}$ is of interest because it is the intermediate formed in the process of nuclear transmutation of $_{92}U^{238}$ to $_{94}Pu^{239}$.

The first pure compound of an artificially-made element that was ever isolated in weighable quantity was that of plutonium ($_{94}Pu^{239}$) in 1942; now relatively large quantities are available.

NAMES OF THE ELEMENTS

The names of elements 93, 94, 95 and 96 were chosen for the following reasons: Neptunium and plutonium are the elements that appear immediately after uranium and are named for the planets in similar order. Americium ($_{95}Am$) is named for the Americas. It has six 5f electrons and is similar to Europium ($_{63}Eu$) which has six 4f electrons and named for Europe. Curium ($_{96}Cm$) is named after the Curies who did the early work on the radioactive elements. It has seven 5f electrons and is similar to gadolinium ($_{64}Gd$) which has seven 4f electrons and was named after Gadolin who did much of the early work on the rare earths.

CHEMICAL PROPERTIES

Previous to 1940 only a very scant amount of data were available on the chemical properties of the heavy elements. With the discovery of the transuranium elements there was a renewed interest in determining the chemical properties of the heavy elements and their compounds which are employed in the tracer and carrier techniques used in determining properties of extremely small quantities of radioactive material; these properties also aided in the classification of the transuranium elements. Particularly was it necessary to determine the chemistry of plutonium and neptunium very completely because of requirements for separation and purification of $_{94}Pu^{239}$ from the other materials in uranium piles. As a result of this it is now stated that the chemistry of plutonium is as well or

better understood than that of most of the elements in the periodic system. However, most of this information is not yet available for publication.

TABLE I

Isotope	Discovery		How Made	Emits	Half-life
	Date	By Whom			
$_{93}Np^{239}$	1940	McMillan and Abelson	$U^{238} + n \longrightarrow U^{239}$ (23 min) $\downarrow$ $Np^{239} + \beta$	β	2.3 days
$_{93}Np^{237}$	1942	Wahl and Seaborg	$_{92}U^{238} + n \longrightarrow {}_{92}U^{237} + 2n$ (7 days) $\downarrow$ $_{93}Np^{237} + \beta$	α	2.25×10^6 years
$_{94}Pu^{238}$	1940	Seaborg, McMillan, Wahl and Kennedy	$U^{238} + {}_1H^2 \longrightarrow Pu^{238} - 2n$	α	50 years
$_{94}Pu^{239}$ (fissionable)	1941	Seaborg, Segre, Kennedy and Lawrence	$_{93}Np^{239} \longrightarrow {}_{94}Pu^{239} + \beta$	α	24,000 years
$_{95}Am^{241}$	1944	Seaborg, James, Morgan	$_{92}U^{238} + \alpha \longrightarrow {}_{94}Pu^{241} + n$ $\downarrow$ $_{93}Am^{241} + \beta$	α	500 years
$_{95}Am^{242}$			$_{95}Am^{241} + n \longrightarrow {}_{95}Am^{242} + \gamma$	β	18 hours
$_{96}Cm^{242}$	1944	Seaborg, James and Ghiorso	$Pu^{239} + \alpha \longrightarrow {}_{96}Cm^{242} + n$	α	5 months
$_{96}Cm^{242}$			$_{95}Am^{242} \longrightarrow {}_{96}Cm^{242} + \beta$	α	5 months
$_{96}Cm^{240}$			$_{95}Pu^{239} + \alpha \longrightarrow {}_{96}Cm^{240} + 3n$	α	1 month

Legend: n = neutrons.
α = alpha particles.
β = beta particles.
γ = gamma ray.
subscript = atomic number.
superscript = atomic weight.

Neptunium has valence states of 3, 4, 5 and 6. This is somewhat comparable to uranium which has valence states of 3, 4 and 6. Greater oxidizing power is required to oxidize neptunium to its higher state than is required for the higher state of uranium.

Plutonium likewise has valence states of 3, 4, 5 and 6 and still greater oxidizing power is required to convert it to its higher state.

The stability of the valence state of 3 increases from uranium to plutonium and it would be predicted that the maximum stability would probably be obtained with curium (element 96) which has seven 5f electrons.

This prediction is verified by data which now indicate that americium and curium probably exist in aqueous solutions in the oxidation state of 3 only.

Curium is the only one of these four elements that has not been prepared in the form of a pure compound.

All of these new elements are strong alpha particle emitters except Np^{237}; consequently Np^{237} is the only one with which it is relatively safe to work in the laboratory without special precautions to avoid health hazards. Cm^{242} has 10^{14} alpha disintegrations per minute per milligram.

The known properties of these transuranium elements make possible a suggested classification of these elements in terms of a new series similar to the rare earth series. This requires a correction of the older classification of elements 89, 90, 91 and 92 which are actinium, thorium, protactinium and uranium. The meager knowledge of the chemical properties of these four elements (89, 90, 91 and 92) indicated that the 6d electron shell was filling in the following manner.

OLD CLASSIFICATION OF ELECTRON ORBITS

at. no.	Element	1s	2s	2p	3s	3p	3d	4s	4p	4d	4f	5s	5p	5d	5f	6s	6p	*6d*	7s
89	Ac	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	*1*	2
90	Th	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	*2*	2
91	Pa	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	*3*	2
92	U	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	*4*	2

If old classification had been correct then the following would be true:

93	Np	(orbits same as above)	*5*	2
94	Pu		*6*	2
95	Am		*7*	2
96	Cm		*8*	2

This would have made neptunium and plutonium similar to $_{75}Re$ and $_{76}Os$ and to elements 43 and 44 whose electronic configurations are

at. no.	Element	1s	2s	2p	3s	3p	3d	4s	4p	*4d*	4f	5s	5p	*5d*	5f	6s	6p	6d	7s
43	Ma	2	2	6	2	6	10	2	6	*5*		2							
44	Ru	2	2	6	2	6	10	2	6	*6*		2							
75	Re	2	2	6	2	6	10	2	6	10	14	2	6	*5*		2			
76	Os	2	2	6	2	6	10	2	6	10	14	2	6	*6*		2			

But they were found *not* to resemble these elements. This has led Seaborg to suggest that the 5f shell (level) is filling instead of the 6d shell (level). The energy of these two levels is almost the same.[1]

This suggestion leads to the following electronic configuration in which actinium becomes the first member of a new series (similar to the position of lanthanum in the rare earth series). This series then has an electronic configuration similar to the rare earth series and should have like properties.

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[1]See Energy-orbital Chart, in Pauling, "Nature of Chemical Bond," Cornell Univ. Press, 1939, p. 26.

NEW CLASSIFICATION (CALLED ACTINIDE SERIES) OF ELECTRON ORBITS

at. no.	Element	1s	2s	2p	3s	3p	3d	4s	4p	4d	4f	5s	5p	5d	5f	6s	6p	6d	7s
89	Ac	filled orbits										2	6	10		2	6	1	2
90	Th											2	6	10	*1*	2	6	1	2
91	Pa											2	6	10	*2*	2	6	1	2
92	U											2	6	10	*3*	2	6	1	2
93	Np											2	6	10	*4*	2	6	1	2
94	Pu											2	6	10	*5*	2	6	1	2
95	Am											2	6	10	*6*	2	6	1	2
96	Cm											2	6	10	*7*	2	6	1	2

These elements can now be compared with the rare earth series which have the following configuration

RARE EARTHS (CALLED LANTHANIDE SERIES)

at. no.	Element	1s	2s	2p	3s	3p	3d	4s	4p	4d	*4f*	5s	5p	5d	5f	6s	6p	6d	7s
57	La	2	2	6	2	6	10	2	6	10		2	6	1		2			
58	Ce	filled orbits						2	6	10	*1*	2	6	1		2			
59	Pr							2	6	10	*2*	2	6	1		2			
60	Nd							2	6	10	*3*	2	6	1		2			
61	Il							2	6	10	*4*	2	6	1		2			
62	Sm							2	6	10	*5*	2	6	1		2			
63	Eu							2	6	10	*6*	2	6	1		2			
64	Gd							2	6	10	*7*	2	6	1		2			
etc.																			

Such a configuration explains satisfactorily the stable valence state of 4 for thorium which compares with a state of 4 for cerium. It also explains the standard valence state of 3 for the rare earths as well as for the actinide series.

It should be noted that the 7s, 6d and 5f energy levels lie so close together that resonance may predominate and determine which level is lowest. Hence the electron configuration may shift from compound to compound.

The question of the difficulty of separation of the transuranium elements may be raised if they have properties similar to those of the rare earths. It is to be noted here that this series has the additional property of radioactivity which makes it possible to affect certain separations on the basis of the difference in the half-life period. This is noticeable with neptunium^{239} (half-life 2.3 days) and plutonium^{239} (half-life 24,000 years).

Addendum: Since writing this paper information has become available on four more new elements, namely, 43, 61, 85, and 87. The report indicates that earlier claims of the discovery of these elements have been disproved and that they exist only as unstable isotopes made by artificial transmutation processes. This completes the list of 96 elements now known. See "Chemical and Engineering News," 25: 431, 1947.

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Address at Symposium on Nuclear Chemistry at the American Chemical Society Meeting at Atlantic City, April 10, 1946.

THE GENUS EXITIANUS IN NORTH AMERICA INCLUDING MEXICO[1]

(Homoptera: Cicadellidae)

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The genus *Exitianus* was erected by Ball in 1929[2] at which time *Cicadula exitiosa* Uhler = *obscurinervis* Stal was designated as the genotype. At that time Ball included *exitiosa* Uhler, *picatus* Gibson and *miniaturatus* Gibson as synonyms of *obscurinervis*. Ball later (1936) described *kinoanus* as belonging to this genus. An examination of the genitalia of this species places it in *Ollarianus*, the male genitalia being almost exactly the same as those of *bullatus* Ball.

At the time that Osborn placed *exitiosus* Uhler as a synonym of *obscurinervis* Stal he published illustrations of the male and female made from the Stal types by Madam Ekblom.[3] An examination of these illustrations in view of the recent studies of materials raises a question regarding the synonomy of *exitiosus*. As a result, *exitiosus* is re-established as a species in the present treatment.

Several thousand specimens collected in Mexico over the past few years have furnished the basis for a study of the species of this genus using the genitalia as a morphologic index of the diverse color patterns and differences in size. The male genitalia are quite similar in type even in the case of species very different in external appearance. The aedeagus and styles are very similar in all the species examined. The pygofers are similar, but the arrangement of the three large spines is apparently indicative of specific types. The pygofer in a few species is distinctive by being shortened and different posteriorly. The female segments are different in several cases and aid in separating certain species such as *picatus* and *excavatus*. It has not been possible to examine specimens of *digressus* V. D.

In addition to treating the previously described species—*obscurinervis*, *exitiosus*, *digressus* and *picatus*—*nigrens* and *tricolor* are described, two species unique in color and form. Also *excavatus* and *abruptus*, two species closely related to *picatus*, are described; and *brevis* and *angulatus* are described as species related to *exitiosus*. In addition two varietal forms of *exitiosus* are being described.

In distribution the species are distributed in relation to altitudes. *Exitiosus* is apparently a low altitude species in both the United States and Mexico. The species described as *nigrens* has been taken only at Cordoba at an elevation of about 2000 feet. Another species described as new, *tricolor*, has been taken at sea level and up to about 2000 feet elevation. *Picatus* has been taken at elevations ranging from 1000 feet to 7500 feet elevation while *excavatus* occurs over the same range of elevations except that it has not been taken at elevations of more than 5000 feet. A species which is described as *angulatus* is apparently a high altitude species and has not been taken at elevations of less than 4000 feet and occurs up to the fir forests at 10,000 feet or more, in such localities as Rio Frio and Desierto de Los Liones. All the species of the genus occur on herbaceous vegetation and are found in the meadows and undergrowth of the forest areas.

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[1]The authors wish to acknowledge with appreciation the assistance obtained from a Grant-in-Aid from the Sigma Xi Research Fund.

[2]Trans. Amer. Ent. Soc., 55:5, 1929.

[3]Annals Carnegie Museum, Vol. 15, Plate 57, Oct., 1924.

THE GENUS

The genus is characterized by a broad, bluntly produced vertex with the margin broadly rounded to the front. The marginal sutures of the clypeus are continuous with those of the front. The appendix of the elytra extend almost around the apical margin. The female ovipositor is usually long, exceeding the pygofer.

KEY TO SPECIES

1. Almost entirely black in color; pronotum, scutellum and elytra without pale markings.. **nigrens**
   Pale in color with dark markings....2
2. Pronotum orange with a transverse black band on posterior half, scutellum orange, unmarked....**tricolor**
   Pronotum pale without a transverse band, scutellum with dark markings....3
3. Margin of vertex marked with two large round black spots....4
   Margin of vertex without black spots....**digressus**
4. Vertex with a heavy black unbroken band between the eyes....5
   Band on vertex narrow, paler in color or broken into spots or bars....7
5. Female last ventral segment truncate or slightly emarginate with a slight tooth at apex. Male pygofer with the spine about half way between ventral and dorsal margins on apical portion....**picatus**
   Female last ventral segment deeply angularly notched almost half way to the base. Spine of apical portion of male pygofer near ventral margin....6
6. Male pygofer shallowly notched or excavated at about two-thirds its length on dorsal margin, apical protrusion of pygofer on dorsal margin....**excavatus**
   Pygofer shorter, sloping at half its length to caudal rounded tip at middle of pygofer.. **abruptus**
7. Vertex margin with black spots next the eyes....**obscurinervis**
   Vertex margin without black spots next the eyes....8
8. Male pygofer concavely excavated on dorsal margin near the apex which is longest on dorsal margin....9
   Male pygofer with dorsal margin sloping ventrally from about half its length to form the longest portion at about its middle....**brevis**
9. Pygofer spine at about middle of pygofer on apical portion....**exitiosus**
   Pygofer spine on ventral portion at about one-third the distance from the apex....**angulatus**

(**Exitianus picatus** Gibson)

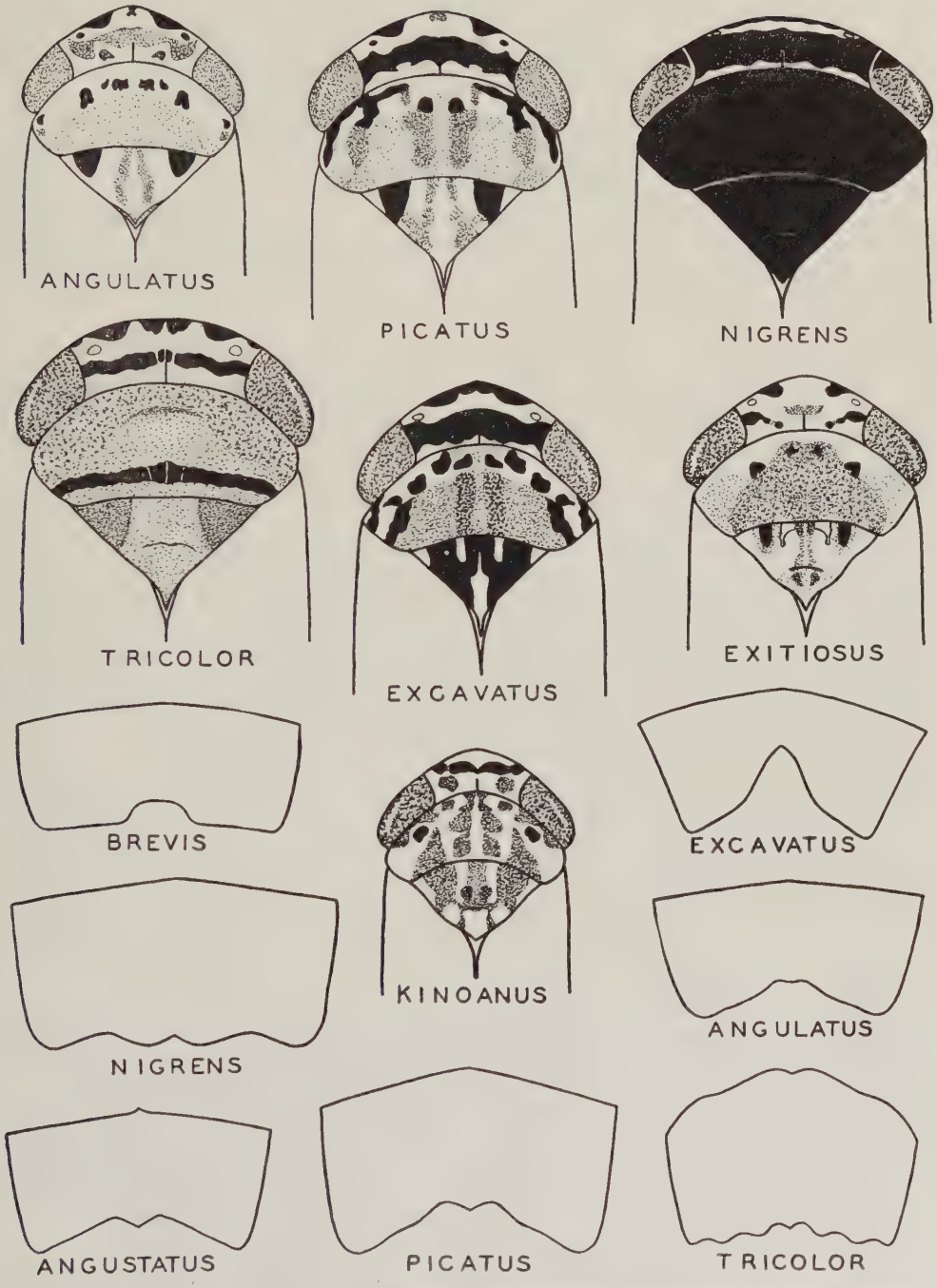
Athysanus picatus Gibson. Proc. Biol. Soc. Wash. 32:26, 1919.
Athysanus minaturatus (Gib.) Proc. Bio.. Soc. Wash. 32:26, 1919.

Resembling *exitiosus* in general appearance but with a broad black transverse band between the eyes. Length 3.5–5 mm.

Vertex broad, slightly produced and broadly rounded, twice as broad between eyes at base as median length.

Color: Vertex creamy with a large round black spot just before each ocellus and a pair of minute proximal spots at apex. A transverse black band of median width between the eyes and just back of ocelli. Pronotum pale with a rather large black spot on anterior portion just behind inner margin of each eye. Scutellum pale with a large black triangular spot in each basal angle and a pair of proximal diverging longitudinal lines on anterior median half. Elytra whitish subhyaline with brown veins. Face pale brown with short dark brown arcs at each side. A broad median longitudinal black stripe extends from the margin of vertex to the base of the clypeus. Marginal lines of clypeus and genae dark brown.

Genitalia: Female last ventral segment with posterior margin shallowly, broadly and rather evenly excavated between the produced lateral angles. Male valve broad and triangular; plates long, triangular, tapered to blunt apices. Style rather broad at base, tapered to a narrow outwardly curved apical tip. Aedeagus erect with a basal short broad process extending dor-



Heads and female last ventral segments of species of *Exitianus* as labeled and *Ollarianus kinoanus*.

sally. The apical two-thirds is tapered from a rather broad base to a pointed apex which reaches the dorsal wall of the pygofer and curves anteriorly. The pygofer is elongate with a deep and broad excavation on the dorsal portion just anterior to the apical dorsal lobe. Three prominent spines are on the pygofer two at the apex, the ventral one of which is shorter and broader, and the spine on the apical portion is about half way between the dorsal and ventral margins.

Specimens of this species are at hand from Iguala, Gro., September 11, 1939; Mexico City, November 20, 1938, and September, 1936; Cuernavaca, Mor., September 8, 1939; Balsas, Gro., December 11, 1939; Tierra Blanca, Vera Cruz, July 29, 1932 (M. F. 2655); Vejuca, Gro., September 3, 1930 (M. F. 1790), collected by Dampf, Plummer and DeLong; Jalapa, S. L. P., K-314, Sept. 22, 1945, DeLong, Hershberger, Elliott; Mexcala, Gro., Oct. 2, 1945, Balock, DeLong, Hershberger and Elliott; Tierra Colorado, Gro., October 5, 1945, Balock, DeLong, Hershberger, Elliott; Cuernavaca, Mor., Sept. 25, 1945, Plummer, Shaw, DeLong, Hershberger, Elliott; Zitacuara, Mich., Sept., 1945, Plummer, DeLong, Hershberger, Elliott.

Exitianus excavatus n. sp.

Resembling *picatus* in general appearance but with a more produced vertex, a broader dark band on vertex and with distinct female genitalia. Length 3.5–4.5 mm.

Vertex produced and bluntly angled almost twice as wide between eyes at base as median length.

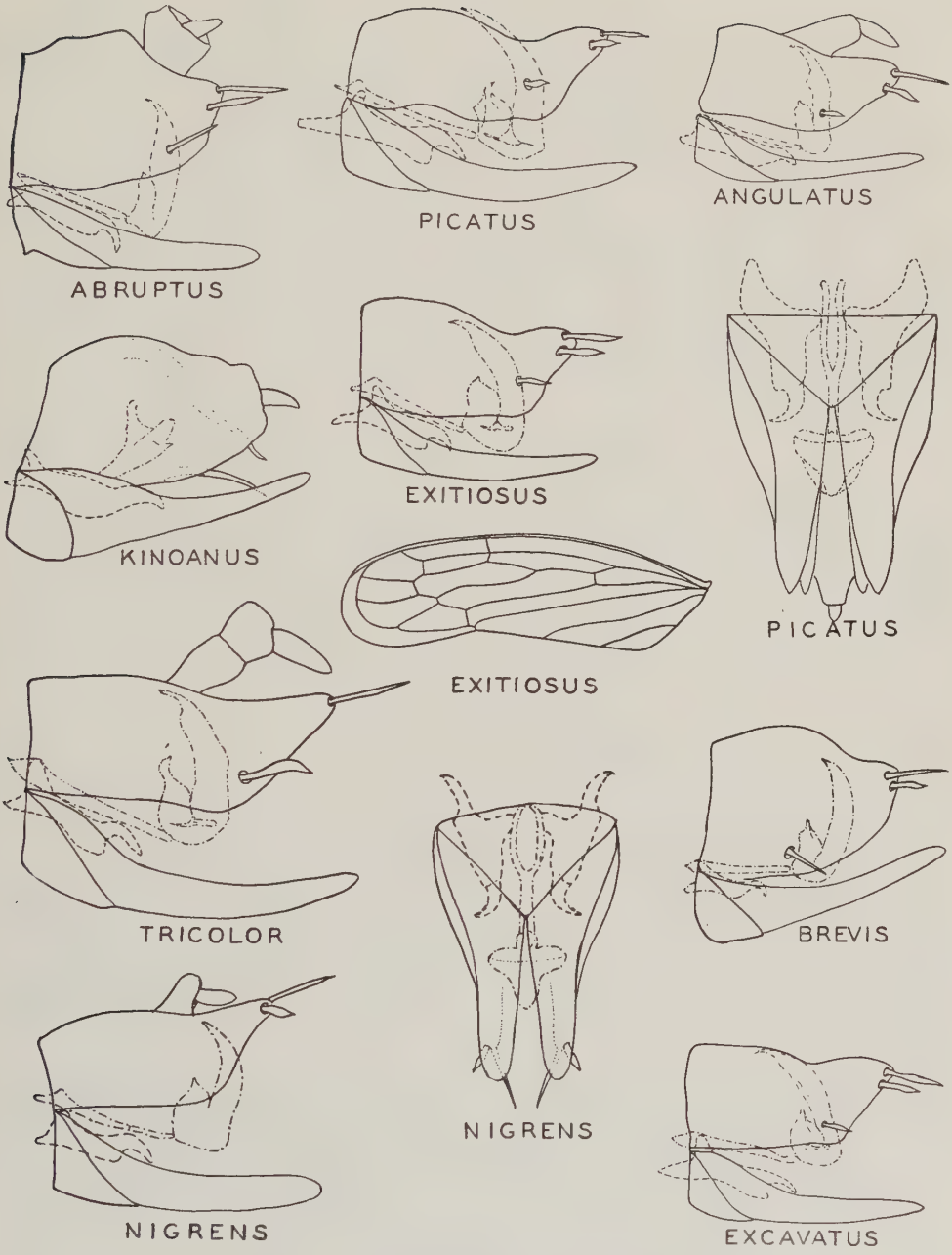
Color: Pale yellow to white with the black of the upper portion of the face showing as a connecting portion between the two large round black spots on the margin of vertex just before the red ocelli. A broad black band just back of ocelli extends between the eyes and reaches almost to the posterior margin of the vertex. Pronotum with a row of large dark spots on the anterior margin and six longitudinal stripes, the median pair broadest and separated by a narrow pale median line. Scutellum black with a median pale longitudinal spot on the posterior half and four pale longitudinal spots on the anterior margin. There is a small one in each basal angle and one each side about equidistant from each other and from each one in the basal angles. Elytra whitish subhyaline, the veins black. Face black with short pale arcs at either side next antennae, a pale line along clypeus and a pale line along margin of each eye.

Genitalia: Female last ventral segment with lateral angles prominent, the median third broadly deeply excavated almost half way to the base. The excavation is broad and V-shaped with the apex rounded. Male valve long, triangular; plates long, narrow, blunt at apex, about one-fourth longer than combined basal width. Pygofer elongate, with a broad convex depression on the dorsal portion at about two-thirds the distance from the base with a pair of apical spines on each side, the ventral spine shorter than the dorsal one. A third spine is located about one-fourth the distance from the ventral margin and not far from the posterior margin. The style is rather broad at the base and narrowed to a sharp pointed out-turned apex. The aedeagus is erect with a short broad basal portion and the apical two-thirds is tapered to a sharp pointed apex which is directed anteriorly.

Holotype male collected at Taxco, Gro., September 9, 1939. Allotype female collected at Zamora, Mich., Mexico, on October 2, 1941. Male and female paratypes collected at Jiutepec, Morelos, September 6, 1939; Cuernevaca, Mor., September 8, 1939; Iguala, Gro., September 6, 1939; Acapulco, Gro., September 10, 1939; Chilpancingo, Gro., September 10, 1939; Taxco, Gro., September 9, 1939, collected by Plummer and DeLong. Paratypes from Finca Vergel, Chiapis, May 15, 1935 (M. F. 4177); Tuxtla, Gutierrez, Chiapis, July 2, 1926 (M. F. 1015); Tequila Jalisco. August 24, 1937, collected by Dr. Dampf. A male paratype from Guadalajara, August 27, 1937, was collected by W. E. Stone. Jacala, S. L. P., September 22, 1945, DeLong, Hershberger, Elliott; Necaxa, Pue., October 26, 1945, Stone, DeLong, Hershberger, Elliott.

Exitianus abruptus n. sp.

Resembling *excavatus* in form and general appearance but with the band between eyes narrower, more broken, on posterior margin and male genitalia different. Length, male 4 mm.



Male genital structures—lateral view as labeled of species of *Exitianus* and ventral view of *Exitianus picatus* and *Exitianus nigrens*. Also the left fore wing of *Exitianus exitiosus* showing the characteristic appendix at apex.

Vertex produced and bluntly angled, almost twice as broad between eyes at base as median length.

Color: Vertex pale with the two large black marginal spots which are joined by the black from the face extending between them. A rather broad black band extends between the eyes. It is irregular on the posterior margin and sends a spur diagonally posteriorly and medially. The pronotum is pale with irregular dark markings extending longitudinally. Scutellum mostly black with white spots in the basal margins and a pair of white spots either side of middle at base and white markings on apex. Elytra pale with dark veins.

Genitalia: Female last ventral segment broadly, deeply excavated about half way to base, the apex of excavation rather broadly rounded. Male valve broad, triangular, the plates exceeding pygofer in length, tapered to blunt apices. Style broad at base narrowed to apices which are sharp pointed and curved outwardly. Aedeagus erect, tapered to a rather sharp pointed apex which is bent anteriorly. The pygofer is a little longer than broad, narrowed both dorsally and ventrally to a blunt apex which bears a pair of spines at the apex and a long ventral spine about one-fourth the distance from the base on apical fourth.

Holotype male and allotype female collected at Jiutepec, Morelos, September 6, 1939, by DeLong and Plummer.

Exitianus obscurinervis (Stal)

Jassus (*Thamnotettix*) *obscurinervis* Stal. Kong. Sven. Vent. Acad. 293, 1858.

This species is apparently closely related to *exitiosus* but according to the illustrations made of the type specimens it is probably distinct. The head is bluntly produced. The margin of the vertex has the two black spots as in *exitiosus* but in addition there is a prominent black spot on the margin next each eye. The band between the eyes is very pale or wanting with prominent spots between the eyes as in *exitiosus*. Length 4–5 mm.

The male and female genitalia are similar in external form to those of *exitiosus*.

The species was originally described from Buenos Ayres, Rio Janeiro.

Exitianus exitiosus (Uhler)

Cicadula exitiosa Uhler. Amer. Ent. 3:72, 1880.

A pale blunt headed species with a broken dark band between the eyes and two round black spots on the margin of the vertex. Length 3.5–4.5 mm.

Vertex blunt, produced, about twice as long between eyes at base as median length.

Color: Vertex pale with a pair of round black spots on margin about half way between vertex and margin of eye. A small spot at vertex and often a smaller spot either side. Ocelli red. A broken transverse band extending between eyes across middle of vertex. Usually with a darker spot at the terminal portions next each eye and a dark spot on either side at base. Pronotum pale to gray with a row of four conspicuous dark spots on anterior portion parallel with the anterior margin. Scutellum pale, a dark triangular spot on each basal angle and a broken line bifid from median basal portion extending to either side of apex. Elytra pale with dark veins and a few dark lines on clavus.

Genitalia: Female last ventral segment with produced lateral angles between which the posterior margin is broadly shallowly excavated with a slightly produced apical tooth at middle. Male valve broadly triangular. Plates long, rather narrow, tapered to blunt apices. The style is rather broad at base narrowed to a slender outwardly curved apical portion which is sharp-pointed at the tip. The aedeagus has a basal portion which is short and broad and which is contiguous with the longer apical portion which extends dorsally and curves anteriorly at the apex. The pygofer is rather long and slender with a prominent rounded indentation on the dorsal portion just anterior to a bluntly produced apical lobe on the dorso-caudal margin. Three prominent spines are on each side of the pygofer; two at the tip of the apical lobe, the ventral one of which is shorter and broader, and a third spine which is shorter than either of the apical spines is located about halfway between the dorsal and ventral margins a little anterior to the apical margin.

This is apparently the proper name which should be applied to the common species which apparently occurs throughout the United States and extends into Mexico. Specimens at hand from many localities throughout the United States show no specific differences. Some of the Mexican specimens are cited as varietal forms of *exitiosus*.

Exitianus exitiosus var. angustatus n. var.

Resembling *exitiosus* in general appearance but more slender and elongate with more produced head and different coloration. Length 4.5–5 mm.

Vertex produced and blunt at apex, more than twice as wide between eyes as median length.

Color: Vertex pale yellowish with a large round black spot just before ocellus on each side of middle on margin of vertex, and a minute brownish spot at apex on the margin. A pale brownish band or a broken band extends between the eyes. This is sometimes reduced to spots, one next each eye and an elongate transverse spot on disc. A conspicuous spot either side on base often connected with the spot next the eye. Pronotum yellow to gray with a pair of median spots on anterior margin and a round spot on anterior portion just back of inner margin of the eye. Scutellum with large triangular black spots extending across basal angles. A median longitudinal stripe divides near anterior end and extends across scutellum forming a pair of divergent stripes on apex. Elytra whitish subhyaline, veins black or dark brown. Face pale brown with dark brown arcs usually interrupted at the middle.

Genitalia: Female last ventral segment slightly and broadly excavated on posterior margin between the lateral angles with a very minute median tooth at apex. Male valve triangular; plates long tapered from base to blunt apices. The styles, aedeagus and pygofer are similar to those of *exitiosus*.

Holotype male, allotype female and male and female paratypes collected at Santa Engracia, Mexico, November 8, 1938, by J. S. Caldwell.

Exitianus exitiosus var. pallidens n. var.

A pale form resembling *exitiosus* but more robust and with different color markings. Length 3.5–5 mm.

Vertex bluntly angled, a little more than one-half times as long at middle as basal width between the eyes. Female more than twice as broad as long.

Color: Creamy with a pair of round black spots, smaller than those of *exitiosus* on the margin of the vertex, just inside ocelli and a small brownish spot at apex; ocelli reddish. A rather narrow pale brownish band extends between the eyes and there is a tiny black spot either side just before the posterior margin. Pronotum pale, the coloration of scutellum showing through on the disc, a small spot just back of inner margin of each eye on the anterior portion. Scutellum creamy with a black triangular spot in each basal angle. Elytra whitish subhyaline, veins pale brown, the median vein on clavus conspicuously brown. Face yellowish with numerous arcs. Those on upper portion of face almost continuous, the veins on the lower portion broadly interrupted at middle.

Genitalia: Female last ventral segment almost truncate, broadly, shallowly excavated from lateral angles to a short, broad, rounded median tooth at apex. Male valve short, triangular; plates long and narrow, about one-fourth longer than combined width at base, tapered to blunt apices. The styles, aedeagus and pygofer are similar to those of *exitiosus*.

Holotype male, allotype female and male and female paratypes collected at Valles, S. L. P., Mexico, August 28, 1939, and paratypes from Tamazunchale, S. L.,P., August 29, 1939, by D. M. DeLong.

Exitianus angulatus n. sp.

Resembling *exitiosus* in general appearance and coloration but with more produced vertex and female segment notched medially. Length 4 mm.

Vertex rather strongly produced and bluntly angled, not twice as wide between eyes at base as median length.

Color: Creamy, vertex with a pair of large round black spots on margin just before reddish ocelli and a small brownish spot at apex. A curved black transverse band, enlarged next each eye, extends between the eyes. The enlarged portion next each eye is connected with an oblique elongated spot extending medially and basally to pronotum. The discal portion of the pronotum is dark and there is a row of rather large irregular black spots on the anterior portion of the pronotum. Scutellum pale, a large black spot in each basal angle. A pair of proximal round black spots at middle and another pair posterior to these just behind the transverse median line. Elytra white subhyaline, veins brown or black. Face pale brownish with dark brown arcs which extend entirely across the face above but are only on the lateral portions of face below.

Genitalia: Female last ventral segment with produced angles between which the posterior margin is sinuate either side of a broad, shallow median rounded notch greater than the width of the ovipositor. Male valve broad and triangularly produced. Plates long and narrow, tapered to blunt apices. Pygofer long and narrow with the concave excavation on the dorsal margin just before apex. There is a pair of spines on the blunt rounded apex. The ventral spine is shorter than the dorsal one. A third spine is on the ventral portion just above margin about one-third the distance from apex. Aedeagus erect with the apex pointed.

Holotype male, allotype female and male and female paratypes collected at Mexico City, D. F., November 20, 1938, by J. S. Caldwell; Toluca Rd., Mexico, November 24, 1938, by J. S. Caldwell; Mexico City, D. F., 18 kms. west, September 1, 1939, and 43 kms. south, September 5, 1939, by DeLong; Mexico City, D. F., September 16, 1936, by W. E. Stone; Jacala, S. L. P., K-314, Sept. 22, 1945, DeLong, Hershberger and Elliott; Tulancingo, Hdg., K-129, October 25, 1945, Stone, DeLong, Hershberger, and Elliott; Rio Frio, D. F., K-65, Oct. 10, 1945, Shaw, DeLong, Hershberger, Elliott; Morelia, Mich., September 30, 1945, Plummer, DeLong, Hershberger, Elliott; Desierto de los Leones, D. F., October 9, 1945, DeLong, Hershberger and Elliott; Rio Tuxpan, Mich., September 29, 1945, Plummer, DeLong, Hershberger, Elliott; Cuernavaca, Mor., September 25, 1945, Plummer, Shaw, DeLong, Hershberger, Elliott; Mexico City, D. F., October 22, 1945, DeLong, Hershberger, Elliott; Zitacuara, Mich., September, 1945, Plummer, DeLong, Hershberger, Elliott.

Exitianus brevis n. sp.

Resembling *angulatus* in general appearance and coloration but with female segment almost truncate with a median shallow excavation and male pygofer short without a dorsal concave emargination. Length 4–5 mm.

Vertex bluntly angled, not quite twice as wide between eyes as median length.

Color: Vertex pale with a pair of large round black spots on anterior margin between which is a smaller spot at apex. The band between the eyes is narrow, broadened on median half, curved anteriorly and sometimes paler in color at middle. A spot either side at base is sometimes connected with the band next the eye. Pronotum with a row of six black spots on anterior margin between the eyes. Scutellum pale with a black triangular spot in each basal angle and a pair of divergent longitudinal stripes at middle which are contiguous at the base and reach the posterior margin on either side of apex. Elytra pale with dark veins.

Genitalia: Female last ventral segment almost truncate on the posterior margin with a rather narrow, shallow, concavely rounded excavation at the middle. Male valve triangular; plates longer than pygofer, elongate, tapered to blunt apices. Style broad at base narrowed to a sharp pointed apex which is curved outwardly. Aedeagus erect, with a short basal portion and a long apical portion which is tapered to a sharp pointed apex; both portions are directed dorsally. The pygofer is short and broad at base, the dorsal margin is concavely narrowed and the ventral margin convexly narrowed at about half its length to form a bluntly pointed apex which bears two prominent spines, the ventral one of which is shorter. A third spine is on the ventral margin at more than half the length of the segment.

Holotype male, paratype male and females collected at Mexico City, D. F., Mexico, November 20, 1938, elevation 7500 feet, by J. S. Caldwell. Allotype female collected at Mexico City, D. F., 43 kilometers south at an elevation of 10,000 feet, September 5, 1939, by Plummer and

DeLong. Paratype female collected on the Toluca Road, 18 kilometers west of Mexico City, September 1, 1939, by D. M. DeLong.

Exitianus digressus (Van Duzee)

Athysanus digressus V. D. Calif. Acad. Sci. 21:32, 1933.

In general form and appearance resembling *exitiosus* but without the black spots on the margin of vertex. Length 4 mm.

Vertex bluntly rounded, more than twice as wide between eyes as median length.

Color: Pale without marginal black spots, the darker forms with a crescent on the vertex above the location of the spots. The band between the eyes is produced anteriorly in triangular form. Elytra pale with pale nervures.

Genitalia: Female last ventral segment with posterior margin feebly sinuate. The male plates long, tapered to blunt apices.

This species is known only from Islands in the lower California region, Chatham Island, James Island and North Seymour Island.

This species has not been available for study but is apparently closely related to *obscurinervis*.

Exitianus tricolor n. sp.

Resembling *exitiosus* in general form but with distinct coloration and genitalia. Length 5–6 mm.

Vertex broadly rounded, scarcely produced, appearing almost parallel margined.

Color: Vertex creamy with a large black spot just before each ocellus on the margin, a pair of smaller proximal spots on margin at apex and a minute spot next each eye. A rather narrow transverse black hand, slightly interrupted at middle extending between the anterior margins of the eyes. Pronotum with an anterior marginal band covering the anterior third. The posterior portion pale with a black transverse band about two-thirds the distance from the anterior margin. Scutellum reddish brown unmarked. Elytra milky white with black veins. Face pale with short brown arcs at either side of face. A rather broad median black band extending from margin of vertex to apex of clypeus. A marginal brown line extends from antennal socket along margins of face and clypeus and a marginal brown line between the lorae and genae.

Genitalia: Female last ventral segment with posterior margin slightly slopingly produced to a faint median notch. Male valve triangular, plates long, tapered to blunt apices. Styles rather broad at base tapered to narrow apices which are curved outwardly and pointed at tip. Aedeagus in lateral view rather broad, bent near base and curved dorsally extending to dorsal portion of pygofer. Apical portion tapered to a pointed tip which is bent anteriorly. Pygofer long and narrow, constricted on dorsal margin anterior to the produced bluntly pointed apex. A long spoon-shaped, spine-like structure arising below middle on ventral apical portion and extending posteriorly. A long single spine is at tip of apex.

Holotype male, allotype female and male and female paratype collected at Buena Vista, Gro., October 23, 1941 (K-340) by Good and DeLong. Male paratypes collected at Acapulco, Gro., November 22, 1938, by Caldwell and a male paratype collected by Dr. Dampf at La Libertad near Flores Peten, Guat., swept from grass in a Savanna region November 23, 1935 (M. B. 146).

Exitianus nigrens n. sp.

A black robust species with few pale markings. More robust and shorter than *exitiosus* and with entirely different coloration. Length 5 to 5.5 mm.

Vertex broad and broadly rounded, appearing parallel margined only slightly produced at middle.

Color: Black. There is a rather broad white band extending between the ocelli just above the anterior margin and a white marginal band on base of vertex. This gives the appearance of a broad black band between the eyes covering most of the vertex behind the ocelli. The

pronotum, scutellum and elytra are shining black unmarked. Face shining black with about four pale spots on lower portion. Beneath black.

Genitalia: The female last ventral segment is almost truncate. The posterior margin is sinuate either side of the median third which is slightly produced and faintly notched at the middle. Male plates slender, elongate; apices distinctly rounded. Valve triangular, extending about to apex of styles. The style is broad at base, gradually narrowed to pointed apex which is bent outwardly. Aedeagus resembling that of *obscurinervis*. There is a short, basal, dorsally produced process which is broad and fits against the dorsally produced apical portion. The latter is rather broad at the base and tapers to a pointed apex which is bent cephalad. The pygofer is concavely narrowed before the apex both ventrally and dorsally to form a narrow protruded apical portion at the tip of which there is a long slender spine just dorsal to a short broad thumb-like spine.

The holotype male and allotype female were collected at Cordoba, Vera Cruz, October 8, 1941, by Good, Plummer, Caldwell and DeLong.

Ollarianus kinoanus (Ball)

Exitianus kinoanus Ball, Bull. of Brooklyn Ent. Soc. 31:72, 1936.

In general appearance and coloration, resembling *exitiosus* but without the apical appendix and other characteristics of *Exitianus*. Length 4 mm.

The vertex is similar in length and width to *exitiosus* and is broadly, bluntly produced.

Color: Pale brownish marked with black and dark brown spots and blotches. A pair of black spots on margin are similar to those of species of *Exitianus*. A transverse band between these crosses the vertex before the anterior margin of the eyes. A pair of dark blotches on the basal portion near the eyes. Elytra white, subhyaline; brown nervures.

Genitalia: Female last ventral segment with the median fourth triangularly produced on the posterior margin. Male plates rather broad at base narrowed and produced to form long, attenuate, slightly divergent apices. The internal structures are almost exactly like those of *Ollarianus bullatus*. The aedeagus is short and broadened at apex with an anterior median and slight posterior processes. The pygofer bears a long dorsal process which arises before the middle and extends caudally and ventrally and tapers to a pointed apex. The ventral process arises at about the middle and extends caudally and ventrally and is shorter than the dorsal process.

Although Dr. Ball described this species as belonging to *Exitianus*, the similarity of the male genital structures to *strictus* and especially *bullatus* leaves little doubt that it should be placed in that genus. It has been taken only in the southwest United States in Tucson and other proximal localities and at Kino Bay, Sonora, Mexico.

Physics of the Twentieth Century

Pascual Jordan has written a fine survey of the concepts of twentieth century physics from his vantage point at the border between theoretical physics and metaphysics. His picture is clearly delineated, well organized, and skillfully presented. It resembles a photograph in that everything is presented from a single point of view. The author develops certain philosophic implications of modern physics and mentions a few experiments which establish his points. Everything else is omitted. Some who look at twentieth century physics will see radios, radar, cyclotrons and other atom smashers, nuclear energy, and a wealth of physical knowledge which has revolutionized the lives and fears of common men. Not Jordan! He sees (a) the development of relativity theory, (b) the evidence that energy is "atomic" in nature, and (c) the uncertainty principle, which has changed the physicist's attitude toward causality and related problems. These theories are of great importance and certainly rank high among the contributions of the past half century, but they do not stand alone.

In the latter part of his book Jordan devotes considerable attention to such topics as the "liquidation of materialism" and "positivism and religion" in which he seems deeply engrossed. For anyone who is interested in the abstract concepts underlying physics, and their relationships in the realm of ideas, Jordan's book is well worth reading.—*John N. Cooper.*

Physics of the Twentieth Century. Pascaul Jordan. Physophical Library, Inc., 15 East 40th St., New York, N. Y. 1946. $4.00.

AN EFFECT OF SUB-LETHAL DOSES OF CRYOLITE ON MEXICAN BEAN BEETLE LARVAE, EPILACHNA VARIVESTIS

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Cryolite, sodium fluoaluminate, is one of the many insecticides used for the control of Mexican bean beetle larvae, *Epilachna varivestris*, and according to the review by Carter and Busberg (1939) it has been generally satisfactory. Being a stomach poison toxic action follows ingestion of the material by the insect. In laboratory tests described by Wene and Hansberry (1944) it was found that many bean beetle larvae did not eat a lethal quantity of cryolite in the 24-hour period allowed for feeding on treated foliage. These survivors showed a marked retardation in growth and development. A similar observation was recorded by Ellisor and Floyd (1939) who noted that some larvae of *Ascia rapae* having fed on cryolite may refuse to feed for several days and shrink considerably in size.

Cessation of feeding for varying periods after ingestion of sub-lethal doses of cryolite may retard development due to inadequate nutrition, something akin to starvation, or due to physiological effects within the insect. A comparison of the effects from starvation and sub-lethal doses of cryolite on instar development of the Mexican bean beetle was the object of the studies reported in this note.

Micronized natural cryolite containing 90% sodium fluoaluminate was the test material. It was applied as a spray to bean leaves in the manner described by Wene and Hansberry (1944), the deposit being calculated as 0.0313 mg. per square centimeter of leaf surface. While under observation test insects were placed in finger bowl type cages at a temperature of 80° F.

Bean beetle larvae were reared en masse in the greenhouse. Third and fourth instars were selected for testing shortly after ecdysis, divided into the necessary number of lots and given the prescribed treatments as indicated in the table. Following the periods of starvation or exposure to cryolite treated foliage, the larvae were allowed to feed on untreated leaves. The untreated foliage was changed daily in order to insure palatibility. At 24-hour periods mortality and instar growth was recorded. Only those individuals succeeding in developing to the next instar were included in the data.

The data in Table I shows that third instar larvae which have fed continuously on untreated foliage had a mean instar length of 2.6 days. One day of starvation increased the third instar length to 3.4 days whereas the third instar length of the larvae feeding for 24 hours on cryolite treated foliage was 4.8 days. The larvae consumed very little of the cryolite treated leaf indicating that the cryolite may act as a repellant. Larvae after being starved for 24 hours ate a large amount of leaf area. Those larvae which had fed on the cryolite treated leaf did very little feeding in the following 24 hours when placed on untreated bean leaf. This decrease in feeding along with the increase in instar length indicates that sub-lethal doses affects the insects metabolism in some other manner than starvation does. Two days of starvation increased the instar length to 4.3 days. The average third instar length of larvae feeding for 2 days on cryolite before being placed on untreated foliage was 5.8 days.

The effect of sub-lethal doses of cryolite was tried on fourth instar larvae. As shown by the Table, feeding cryolite for one and three day periods lengthened the instar period more than equal periods of starvation did.

Five third instar larvae consumed approximately 80 per cent of the area of a single leaf in a 24-hour period. About the same amount was consumed in the second day of feeding. Five third instar larvae after one day of starvation consumed about 80 per cent of the area of two leaves in a 24-hour period. Five larvae ate less than two per cent of the leaf area of a cryolite treated leaf in a 24-hour period. These five larvae ate about the same amount of untreated foliage in the next 24-hour period. This brings up a point overlooked many times in field control experiments in that the potential injury of the surviving larvae is reduced and that cryolite may be more effective than the mortality records indicate.

TABLE I

THE EFFECTS OF STARVATION AND SUB-LETHAL DOSES OF CRYOLITE ON THE GROWTH OF MEXICAN BEAN BEETLE LARVAE

TREATMENT*	THIRD INSTAR			FOURTH INSTAR		
	Number Larvae	Per Cent Survival	Mean No. Days of Instar	Number Larvae	Per Cent Survival	Mean No. Days of Instar
Fed continuously	55	100.0	2.6	35	97.1	5.3
1 day of starvation	55	100.0	3.4	34	94.1	6.5
1 day of cryolite treated leaves	93	47.3	4.8	55	61.4	8.1
2 days of starvation	47	76.8	4.3	.....	.....	.....
2 days of cryolite treated leaves	93	44.1	5.8	.....	.....	.....
3 days of starvation	.....	.....	.....	34	79.1	9.3
3 days of cryolite treated leaves	.....	.....	.....	65	24.7	10.3

*After treatment larvae were fed on untreated foliage.

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PROVISIONAL PALEOECOLOGICAL ANALYSIS OF THE DEVONIAN ROCKS OF THE COLUMBUS REGION

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INTRODUCTION

To anyone who collects carefully from the Devonian rocks in the Columbus region, it is soon evident that while there are many fossils that occur in all of the zones of the limestones, there is none that extends from them upward into the overlying Olentangy and Ohio shales. Further study shows that many species are found only in certain sets of strata of the Columbus and Delaware formations. There are two reasons for this distribution: time and change. The time that elapsed while the limestones and shales were being deposited was very long, possibly as much as 20,000,000 years. During this time many species died out (extinction), new species developed (filiation), other species came in from elsewhere (migration), and some species carried on without significant change (propagation). But all during this time conditions in the local seas were constantly changing—minor changes during the deposition time of the Columbus formation, distinct changes beginning with the Delaware, and great changes in Olentangy and Ohio time. The environments and sea-climates in which the marine communities (biocoenoses) lived changed. Many species could live only in certain conditions of bottom (sediments), depth, temperature, dissolved oxygen, illumination, salinity, neighbors, etc. When all of these, or any of these, changed, species either died out if they could not become adjusted to the new situation, or migrated elsewhere. The long-ranging forms (tycoen), such as *Leptaena*, *Atrypa*, *Megastrophia*, evidently could make these adjustments and stuck it out until the situation became too difficult even for them. Short-ranging types (eucoen), like *Nucleocrinus*, *Goldringia*, colonial corals, and many other zone fossils, flourished only while their environment remained at an optimum. To distinguish between the effects of time and change in segments of the geologic past is never easy, and here an attempt will only be made to point out some of the significant environments (biotopes) and their organic communities (biocoenoses) as they are revealed by the rock records of the environments (lithotopes) and their fossil contents (thanatocoenoses). The complete reconstruction of an ancient community is of course practically impossible for a lithotope never contains fossils of all the various organisms of the original biocoenose, only the remains of the few forms equipped with shells or skeletons of some sort.

The analytical columnar section (Figure 1) for the Devonian rocks of the Columbus region will serve to focus the relative positions of the lithotopes to be discussed below. The alphabetical zonation is that established by C. R. Stauffer in 1910; the zone fossils are in part his, and in part, suggested here.

DISCUSSION OF LITHOTOPES AND BIOCOENOSES (THANATOCOENOSES)

Normal Limestone Lithotope:

Here are included the relatively pure limestones of the Delhi member (Zones E, F, G, H), throughout which the same general type of fossil assemblage persists with faunule modifications due to the time factor. The biotope during this time was nearly constant,—warm, clear, shallow, well-illuminated, quiet sea-water

of normal salinity.[1] The richly-speciated faunules were composed of mostly benthonic types, comprising several interlocked layer-societies or associations of different bottom levels; the burrowing animals, especially pelecypods (*Conocardium* and *Modiomorpha*); forms living directly on the bottom, fixed or crawling, such as brachiopods, small corals and bryozoa, gastropods and trilobites; forms raised off the bottom by stems or ramose growth modes, such as blastoids, crinoids, large horn corals, colonial corals; and the bottom hugging swimmers (nektobenthon), the frilled, breviconic, and orthoconic cephalopods.

In this "normal" environment flourished the large, heavy-shelled gastropods (*Pleuronotus*, *Turbonopsis*, *Palaeotrochus*) and large nautiloides,—forms which are almost completely absent from higher or lower beds. The corals of this biotope are almost exclusively types suited to a soft bottom lacking solid points for fixation: many species of horn corals and such honeycomb corals with pear-shaped colonies as *Favosites hemisphericus*, all of which lay loose on the substratum. This is in strong contrast to the bushy and sprawling types with fewer free horn corals of the coral biostromes of Zone C.

The mottled weakly pelmatozoic limestones of Zone G show pronounced differential weathering due to the presence of thick, finger-like, anastomosing networks of finer, more-easily weathered material. This may be the highly triturated faecal material of crawling or burrowing detritivores analogous to the modern holothurians, but there is no more direct evidence of these lowly members of the "normal" communities.

Facies α. An interesting facies of the normal environment exists in the upper part of the Delhi member (Zone H). Layers of limestone are composed largely of pelmatozoan remains,—*Nucleocrinus*, crinoid and blastoid stem fragments, and occasional large crinoid heads (*Dolatocrinus* and *Megistocrinus*). Other members of the "normal" biocoenose are not lacking, but are reduced in numbers. From time to time during the deposition of Zone H large patches of the bottom must have been covered by "colonies" of crinoids and blastoids swaying on their stems, the dominants of this society. Sediments accumulated so slowly that rapid burial, necessary for preservation of blastoids and crinoids with stems still attached, did not obtain. The action of scavengers in disarticulating stems and other parts made such preservation even more unlikely. The crinoids were all camerates with stout stems and large calices about the size of peaches. A special associate of these crinoids was the large spiny gastropod, *Platyceras dumosum*. This handsome species belongs to a Devonian genus whose species nearly always occur with crinoids, often actually attached to the calice. This constant association is often considered to have been parasitic but may well have been the more mutually beneficial arrangement, symbiosis.

Another example of Facies α, the crinoid-*Platyceras* layer society, is the thin crinoidal lens in the lower part of the Delaware formation at the Miami quarry, on the Olentangy River two miles north of Bartholomew Run. This is a very restricted occurrence and seems to represent a temporary and local re-establishment of Columbus (Delhi) biotopic conditions. The crinoids are small, and likewise all specimens of *Platyceras* and the closely related *Orthonychia* are small. This thanatocoenose, however, is not a recurrence of any of those of the Delhi, and is quite distinct from those of the rest of the Delaware. It is analogous to that of Zone H, and homologous to that of the Prout limestone of northern Ohio,—a nice instance of homologous lithotopes with analogous thanatocoenoses due to the time factor.

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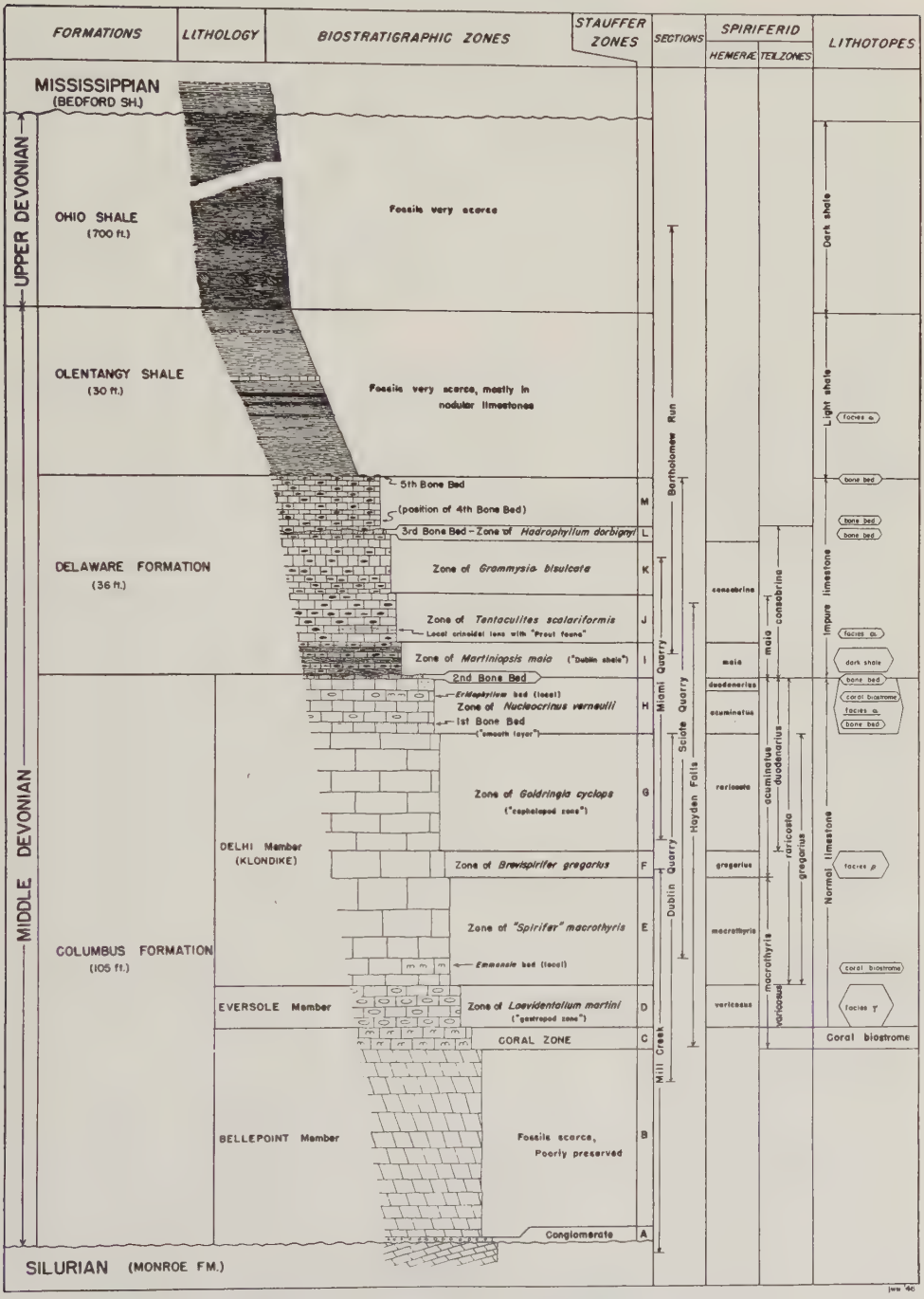
[1]That is, normal salinity for the seas of Devonian times, which must have been appreciably less saline than modern seas.



BIOSTRATIGRAPHIC ANALYSIS OF COLUMBUS DEVONIAN SECTION

FIG. 1. Biostratigraphic analysis of Columbus devonian section.

Facies β. The concentration of *Brevispirifer gregarius* in vast numbers of Zone F represents another facies, one characterized by bottom-lying brachiopods,—a "brachiopod bank." This species is found not only in this zone, but also in the ones just below and above but in much smaller numbers. During the time of Zone F in this region, however, *B. gregarius* reached its local acme and flourished almost to the exclusion of other forms,—a single dominant layer-society. This distribution is a good example of the biostratigraphic concept of the hemera, the acme time of a species, the epibole, the deposits accumulated during the hemera, and the biozone (or more accurately, teilzone), the complete duration, in strata, of a species, thus: the *gregarius*-biozone (teilzone) extends through Zones E, F, and G, the Zone F epibole was deposited during the *gregarius*-hemera. Similarly Zone E is the *macrothysis*-hemera, Zone G the *raricosta*-hemera, while Zone H includes two hemerae, the *acuminatus* in its lower part, the *duodenarius* at its very top, all based upon spiriferids.

The occasional occurrence of conchs of *Goldringia* in the midst of these departed brachiopod hosts of Zone F suggests that this cephalopod may have been a raider that found these banks especially good feeding grounds.

Facies γ. The Eversole chert member, just below the Delhi member, with its lithotope facies of fossiliferous white or gray chert, contains the largest number of species of any unit. Among the 85 species now known, many of those of the "normal" limestone lithotope make their first appearance. Environmental conditions of this lithotope, except for the still practically unknown factors that brought about the periodic accumulation of layers of silica, were the same as for the normal limestones. It would seem that the richness of the faunule is due to the chert rather than a biologic factor. That is, the benthonic biocoenose of the Eversole differed from later ones only insofar as the time factor is involved; the thanatocoenose, however, because of more favorable conditions of preservation, contains many forms unknown or very scarce in other lithotopes.

The most important feature of the Eversole facies thanatocoenose is the large number of species of gastropods,—30, about triple the usual number of the "normal" limestones. Especially abundant are bellerophontids and pleurotomariids. The thinness of the shells of these forms made them particularly liable to destruction before burial and elimination during diagenesis. In the limestones it is rare to find a gastropod with some of its replaced shell. Most are steinkerns. The same applies to the pelecypods, with the exception of the heavy-shelled *Conocardium*.

Chert is not confined to the Eversole member, and is common in Zone H and throughout the Delaware formation. However, in these higher horizons it is almost wholly unfossiliferous except in the bone beds. In the Eversole member the chert was probably a syngenetic silica gel; in the higher members it is of secondary origin, replacing the limestone and appearing as concretionary masses.

Coral Biostrome Lithotope:

True coral reefs do not occur in the limestones of the Columbus region, but in Zone C, the upper few feet of the Bellepoint member, corals are so numerous as to form a large part of the zone and qualify as a biostrome. The lithotope, a brown magnesian limestone with a thanatocoenose of many species of tabulate and rugose corals and stromatoporoids, represents an environment especially favorable for the development of hermatypic corals. Two layer-societies are here commingled, the primary one being that of bottom-hugging types such as horn corals and innumerable large sprawling stromatoporoids, with many of the usual benthic forms of the "normal" limestone biotope. This basal society provided firm sites for the fixation of larger coral colonies which grew away from the bottom to a

height of two or three feet; colonial rugosa such as *Diphyphyllum, Synaptophyllum* and *Cylindrophyllum,* large massive and ramose tabulates such as *Favosites, Emmonsia,* and *Cladopora.* The stimulus for the development of these lotic types was probably more agitated water than prevailed during the deposition time of the higher members.

At a few localities small biostromes of the secondary colonial coral layer society, usually the species *Eridophyllum seriale,* occur a few feet from the top of the Delhi member. One such occurrence is in the old Marble Cliff quarry on the east side of the Scioto River, and similar ones in apparently the same stratigraphic position are found sporadically as far north as Sandusky. Limited biostromes of the massive tabulate, *Emmonsia,* are found at a few places a few feet above the Eversole chert member.

Bone Bed Lithotopes:

The five bone beds of the Columbus and Delaware formations are records of a biotope distinctly different from the preceding. They are thin layers of fragmentary fossils, mostly of small size, and mostly crinoidal or pelmatozoic, mixed with bones, scales, teeth and bits of armor plate of fishes, button corals; the whole forming a coarsely granular, "sandy" limestone. They represent, not the lime-mud depositing conditions of the great bulk of the limestones, but epochs when the sea-bottom was above the base of wave action and fine-grained muds could not accumulate. Erosion (subaqueous) rather than deposition was the order of the day. Under these conditions the bone beds are the concentrated coarse residue of perhaps many feet of lime muds. In places they rest on mud-cracked limestones, indicating occasional exposure.

The bone bed lithotopes record a sandy bottom biotope, a favorable environment for certain benthonic communities. But the composition of these biocoenoses is poorly known because of the slowness of burial and effects of detritivores and scavengers. The fish remains are all of fresh-water forms borne in from Cincinnatia. They are thinly diffused throughout the limestones and concentrated in the bone beds. They are not records of periodic catastrophic annihilation of shoals of marine fishes, as often supposed. Most of the other fossils are the regular eurytropic species of the limestone lithotopes,—species widely adapted to a variety of benthonic situations. In other words, the bone beds have no special faunules, with the possible exception of ostracods, for whom the sandy bottoms were evidently suitable, and the curious stenotopic button-coral, *Hadrophyllum d'orbignyi,* which flourished only on sandy bottoms.

Impure Limestone Lithotope:

This lithotope extends generally through the Delaware formation and especially in Zones J, K, and M. It consists of argillaceous blue to brown limestones, with many scattered dark chert bands, and represents a biotope much less favorable to organisms than the clear waters of the Delhi member. The water was still shallow, but cooler and turbid with fine mud. The thanatocoenoses of less than half as many species in the various zones compared with those of the Delhi member indicate equally reduced biocoenoses. Notable is the practically complete absence of groups common in the normal limestone lithotopes: tabulates, rugose corals, stromatoporoids, blastoids, crinoids, gastropods, cephalopods and trilobites. The faunules consist mostly of brachiopods and pelecypods. The impoverished biocoenoses comprised three main layer-societies: the bottom burrowers or plowers such as *Lingula, Grammysia,* and *Nyassa,* the sessile benthonic forms such as most brachiopods and *Glyptodesma,* and occasional shoals of nektonic gastropods (pteropods) such as *Tentaculites.* The stratal distribution of these is different

from that in the normal limestones. Instead of being well-mixed assemblages of many species, species commonly occur singly but in large numbers of individuals. Slabs of the Delaware are commonly found covered by hundreds of *Tentaculites scalariformis*, or *Leptaena rhomboidalis*, or Spirifers, *Grammysiae*, *Glyptodesmae*, etc. This fewness of kind with local abundance of individuals is characteristic of waters of abnormal salinities, boreal environments, or very muddy bottoms, as against the abundance of kind with fewer individuals of warm, clear, normally-haline environments. In the present case there is some indication of subhaline conditions during Delaware time, such as the shale facies of Zone I, which has, however, a thanatocoenose distinct from those of the more calacreous lithotopes under consideration. Colder water may account for the great reduction or disappearance of such stenothermic types as corals and crinoids, but not for such eurythermic forms as trilobites, gastropods, and cephalopods. Further and closer study of the Delaware faunules is necessary before a satisfactory resolution of the biotopes can be made, but it is likely that they were subhaline, not so much as in Zone I, and somewhat cooler and decidedly muddier than those of the Delhi. The occurrence in the Delaware of layers such as the bone beds and other crinoidal lenses, containing normal-haline clear-water thanatocoenoses, further emphasizes the distinctness of this lithotope.

Dark Shale Lithotope:

These are exemplified by the Ohio shale and the "Dublin shale" phase of Zone I of the Delaware, and are essentially nearly unfossiliferous bituminous shales. The Ohio shale is black; that of Zone I is dark brown. Both are lithotopes indicative of brackish-water environments; both contain analogous thanatocoenoses of a few species of thin-shelled bracjiopods (*Leiorhynchus*, *Lingula*, and *Orbiculoidea*) with occasional euryhaline wanderers. *Lingula*, a mobile form, lives in muddy bottoms, the others were sessile and probably fixed to seaweed. Conditions were quite impossible for other groups such as corals, crinoids, trilobites, cephalopods, etc. They were less rigorous in the Dublin shale biotope than in that of the Ohio shale, where the blackness of the deposit with much pyrite indicates foul water with very low oxygen content. Fossils are fairly common in the Dublin shale and have the characteristic brackish-water facies of few species and many individuals. In the Ohio they are very scarce, and are significant only in the Bellefontaine outlier some 50 miles to the west of the Columbus region, nearer the old shore of Cincinnatia. Here there are several layers near the base of the formation crowded with individuals of *Lingula*, *Orbiculoidea*, *Leiorhynchus* and *Chonetes*, together with the vast numbers of *Styliolina*. The last may represent pelagic dwellers in the better-aerated surface waters. The fish remains of the Ohio, like those of the Middle Devonian limestones, are not those of endemic marine forms, but remains of stray carcasses drifted in from the streams of Cincinnatia. The same origin also applies to the occasional plant remains in the Ohio. Some of the silicified logs of *Callixylon* bear traces of attached or entangled crinoids (*Melocrinus*) that they bore while floating at the surface of the foul-bottomed sea.

The Dublin lithotope is a dark shale facies which passes laterally into the impure limestones of Zone I. These limestones carry the usual thanatocoenoses of the higher zones of the Delaware. Species of the Dublin thanatocoenose likewise pass laterally into the limestones, but those of the limestone do not extend into the shale. The screening off of the biocoenose of the lime mud areas from that of the contemporaneous dark mud areas was probably due to differences of bottom, salinity, and aeration, but mingling in the opposite direction was possible because of the greater environmental tolerance of the species of the brachish-water biotopes.

Light Shale Lithotope:

The Olentangy shale, a slightly calcareous gray-green clayey shale with thin layers of impure limestone, is nearly unfossiliferous. Fossils, except for microscopic forms (ostracods, conodonts, and plant remains), are found almost exclusively in the nodular pyritiferous limestones. The presence of one or two thin layers of black shale in the Olentangy and of occasional layers of green shale in the lower part of the Ohio shale suggest that the Olentangy is a basal phase of the Ohio. Its thanatocoenose consists of a very few forms indicative, not of the brackish-water biotope of the Ohio, but a very impoverished nearly normally saline but uncongenial biotope; one or two small rugose corals, a few bryozoans, several tolerant brachiopods (*Lingula*, *Chonetes*, *Ambocoelia*), an orthoconic nautiloid, and goniatites (*Tornoceras* and *Manticoceras*), and a few others. Neither species nor individuals are abundant. Seemingly this was a depauperate biocoenose of the normal benthonic type eking out a ragged existence against stifling fine muds, most of the time driven out by mud, returning during the brief intervals of reasonably clear water represented by the thin limestones. Occasional crinoid plantations did exist, notably the one at the type locality of the shale near Delaware,—a lens several inches thick of comminuted remains of the large *Melocrinus bainbridgensis*, a species also found in the green layers near the base of the Ohio shale and the probable pseudobenthonic associate of the *Callixylon* logs of that formation.

SUMMARY PALEOECOLOGICAL ANALYSIS BY LITHOTOPES

1. *Normal limestone lithotope:* fine-grained to somewhat crystalline nearly pure limestone, usually thick-bedded, locally weakly pelmatozoic.

   Biotope: normally saline, warm, quiet, clear, shallow water below base level, bottom mainly mud.

   Biocoenose (*thanatocoenose*): richly speciated benthonic multilayered society of rugose corals, crinoids, byrozoans, brachiopods, large gastropods, large cephalopods, and trilobites.

   Distribution: Delhi member.

   Facies:

   α—crinoidal limestone.

   Biotope: as above, but sandy bottom.

   Biocoenose (*thanatocoenose*): crinoid-blastoid-*Platyceras* layer society dominant.

   Distribution: Zone H of Delhi member, and Miami Quarry lens of lower Delaware formation. Also the thin crinoid lens in the Olentangy shale at Delaware.

   β—brachiopod limestone (*gregarius*-hemera).

   Biotope: as above.

   Biocoenose (*thanatocoenose*): sessile brachiopod layer-society dominant.

   Distribution: Zone F of Columbus formation, Delhi member.

   γ—fossiliferous gray-white chert.

   Biotope: as above.

   Biocoenose (*thanatocoenose*): multi-layered benthonic society, richly speciated, gastropods dominant.

   Distribution: Eversole chert member.

2. *Coral biostrome lithotope:* brown magnesian limestone crowded with corals.

   Biotope: as in normal limestone biotope, but water more agitated.

   Biocoenose (*thanatocoenose*): dual-layered, lotic coral society dominant.

   Distribution: Zone C; minor occurrences in Zones E and H.

3. *Bone bed lithotope:* crinoidal limestone with heavy concentration of fish remains.
   Biotope: as in normal limestone ,but water agitated, bottom sandy and above wave base.
   Biocoenose (thanatocoenose): dual-layered society, mostly eurytropic forms, dominant.
   Distribution: five bone beds in Delhi member and Delaware formation.
4. *Impure limestone lithotope:* argillaceous blue-brown limestone with chert layers and thin shale bands.
   Biotope: salinity slightly subnormal, cool, muddy water below wave base.
   Biocoenose (thanatocoenose): triple-layered benthonic societies ,restricted faunules, few species, individuals locally abundant.
   Distribution: generally throughout Delaware formation.
5. *Light shale lithotope:* slightly calacreous green-gray shale with thin layers of impure, pyritiferous limestone.
   Biotope: normally saline, warm, but very muddy water below wave base, subnormal oxygen content.
   Biocoenose (thanatocoenose): depauperate, multi-layered society, species and individuals few.
   Distribution: Olentangy shale.
6. *Dark shale lithotope:* brown to black, often pyritiferous, bituminous shale.
   Biotope: brackish water, often foul and poorly aerated except superficially, muddy, below wave base.
   Biocoenose (thanatocoenose): few species of thin-shelled types, with individuals locally numerous, forming two or three layer-societies (surface, on bottom, and in bottom).
   Distribution: Ohio shale and locally in Zone I of Delaware formation.

GALVANOTROPIC RESPONSES OF PARAMECIA TO BALANCED SQUARE WAVES

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Galvanotropism in *Paramecium* has been extensively studied in respect to many variables. Jennings (1906) reviews the earlier investigations and comes to the conclusion that reaction is due to the reversal of effective ciliary stroke on the cathodal surface of the organism. Bancroft (1906) observed that certain salts when added to the environment will cause forward locomotion toward the anode. Stratkewitsch (1907) observed internal pH changes under direct and alternating current. Scheminsky (1926) and Hausman (1929) discussed movement in varying sinusoidal alternating frequencies. Kamada (1928–31) reported on galvanotropism with controlled "current strength," "salt intensity," and time factors. Much quantitative work has been done in respect to direct, interupted direct, and sinusoidal alternating current of varying frequencies.

The quantitative and qualitative studies made possible by electrical stimulation is fully recognized. In order for electrical stimulation to be of value in quantitative studies it is necessary that the current be constant and any interchange instantaneously opposite. This is possible by the use of a balanced square wave as described by the authors in their previous paper (Goldston and Miller, 1947).

PROBLEM

In the behavior laboratory, keeping *Paramecium caudatum* in a normal environment, we applied frequency controlled, balanced square waves, the electrochemical results of which were equal and opposite (Goldston and Miller, 1947). In keeping all other factors constant except frequency of polarity interchange, we observed the reactions of paramecia subjected to frequencies from zero to one hundred thousand cycles per second.

APPARATUS

The method for production of balanced square waves was discussed by the authors in a previous number of this *Journal*. The electronic wave form made available by such mechanisms was found to be applicable to studies in protozoan behavior.

The electrodes were introduced into the ends of an elongated U-shaped culture tube (see Figure 1). A constant plane-to-plane voltage of 45 volts was applied to the culture which approximated 200,000 ohms resistance at all times. This permitted the flow of 0.155 milliamperes. This amperage to which the paramecia were subjected was sufficient to produce definite cathodal galvanotropism without any morphological distortion. Balanced square waves from .25 to 5 cycles per second were produced through the use of the electric dpdt relay. Frequencies from 5 to 100,000 cycles per second were provided by a variable square wave generator.

APPLICATION

A standard culture of *Paramecium caudatum* was secured for the experiment. The organisms were placed within the U-tube and observed through a binocular microscope. The same culture source was used throughout the experiment with frequent changes of samples. Temperature was kept constant at 21° C. Throughout the range of frequencies studied a consistent sample reaction of almost 100% could be noted.

Upon the application of a direct current an almost 100% cathodal movement was noted. The morphology of the individuals was normal. With an instantaneous interchange of polarity, there was an immediate orientation toward the new cathode (see Figure 2).

When the frequency of polarity interchange occured at intervals of two seconds, individual paramecia in following the cathode traversed an ellipse (see Figure 3).

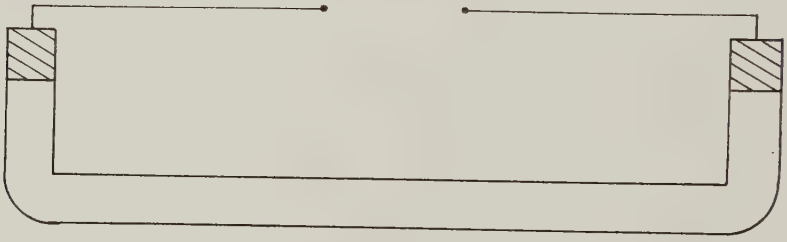

FIG.1

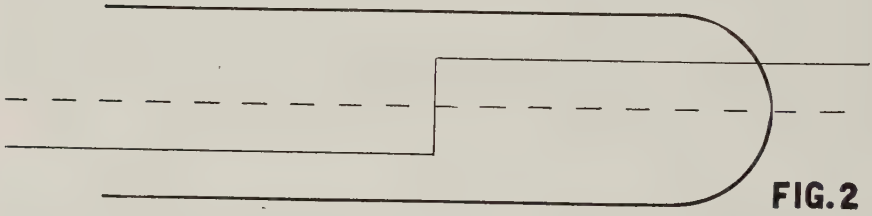

FIG.2

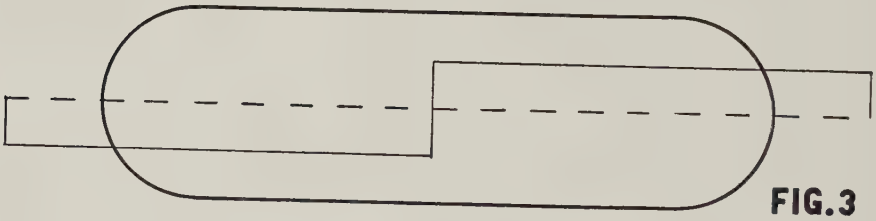

FIG.3

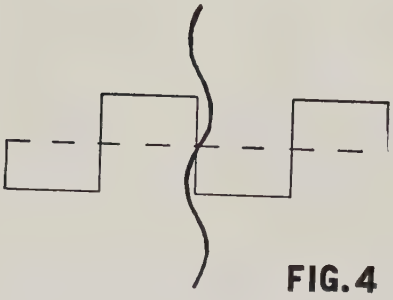

FIG.4

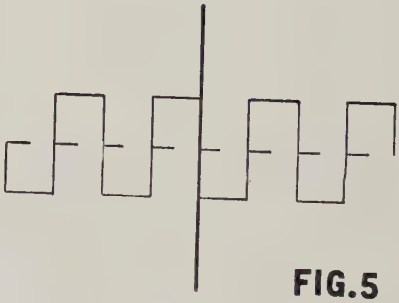

FIG.5

FIGURE 1. Culture tube used in observation.

FIGURES 2–5. The paths taken by Paramecia in response to electronic stimulation in relation to the frequency of the balanced square waves. The orientation to a new direction in each instance starts at the point of polarity interchange (not illustrated). See text for details.

Increasing the frequency of polarity interchange to 0.9 seconds resulted in mass movement at right angles to electron flow. The course followed by individuals when subjected to the above frequency was slightly sinusoidal in relation to the tempo of interchange (see Figure 4).

At frequencies of three cycles per second, the general movement continued to be at right angles to current flow, slow forward locomotion was observed with the exception of a few individuals which remained stationary rotating on their long axis.

At a frequency of ten cycles per second a rather smooth path was followed at right angles to the current flow (see Figure 5). Movement was somewhat faster and there was some individual pin-wheeling. Paramecia continued to respond in a like manner throughout the range to five hundred cycles per second. During this change in frequency, individuals were observed to approach normal locomotor speeds. At the upper limits of the range a few individuals were noted to move parallel to current flow for short distances.

From 500 to 1080 cycles per second, the frequency was increased in steps of sixty cycles. The behavior at 1020 was essentially the same as that observed for 500 cycles per second. At 1080 cycles per second perfectly normal behavior was observed. There being no change in behavior between periods when electronic stimulation of this frequency was applied, and when all electronic stimulation was removed. The behavior of the paramecia which appeared to all intent to correspond to the normal behavior at 1080 cycles per second was not altered through further increases in frequency to 100,000 cycles per second.

SUMMARY

Paramecia exhibit definite cathodal galvanotropism when subjected to direct current at low amperage. When stimulation is in the form of balanced square waves, the electro-chemical results of which are equal and opposite, and varying only the direction and duration of electron flow, the organisms were observed to alter their reactions in response to frequency variation.

At the lowest range of frequencies tested, paramecia move parallel to electron flow, reversing direction upon polarity interchange, thereby travelling in an elongated elliptical path, the long axis of which is parallel to electron flow.

Increasing frequency of polarity interchange shortens the long axis of the elliptical path, finally reaching a point where both axes are equal and the path is circular.

Increasing the frequency of polarity interchange beyond this point and up to 1080 cycles per second paramecia traverse a path at right angles to electron flow. At 1080 cycles and beyond there is no discernable difference in behavior between paramecia subjected to the current and paramecia in the normal culture.

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NEW ZYGNEMATACEAE FROM ECUADOR

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The freshwater algae of Ecuador have received very little attention, especially during the past fifty years. Such notices as have appeared are very brief and there have been no extensive lists to convey even a general idea as to the species which exist there, and their distribution. This is partly because the botanists of the country and those who have traveled in Ecuador have had their attention justifiably occupied by the very rich and seemingly inexhaustible terrestrial flora. It is not surprising, therefore, that algal collections, especially from the interior wilds, should yield additions to the records for Ecuador, and new or otherwise interesting species.

While on quinine exploration for the U. S. Government the author had occasion to make a few collections of algae, mostly from alpine regions. One habitat was a series of hanging bogs among old, grass-covered hills of volcanic ash on the flanks of Volcano Cotopaxi. This towering mountain rises in the eastern cordillera about 50 K. southeast from the capital city of Quito, itself located high on the inter-Andean plateau. The hanging bogs and shallow ponds visited on Cotopaxi varied in altitude from 12,500 to 14,000 feet. Most of them were grassy and some were carpeted with moss. One pond in particular, apparently somewhat acid, was very rich in variety of species, especially desmids. Scarcely any Oedogoniaceae were fruiting, and of the many Zygnemataceae only a few were in identifiable condition. Three of these species, described below, were new and seemed worthy of publication as preliminary to a subsequent more extensive report on the algae of Ecuador.

The author is greatly indebted to Dr. E. N. Transeau for his assistance in making identifications and preparing descriptions, and to Dr. Hannah Croasdale for Latin diagnoses. Also acknowledgments are due the Muellhaupt Fellowship, Ohio State University, where studies of the Ecuadorian collections were conducted.

Mougeotia chlamydata, sp. nov., Pl. I, Figs. 9–11.

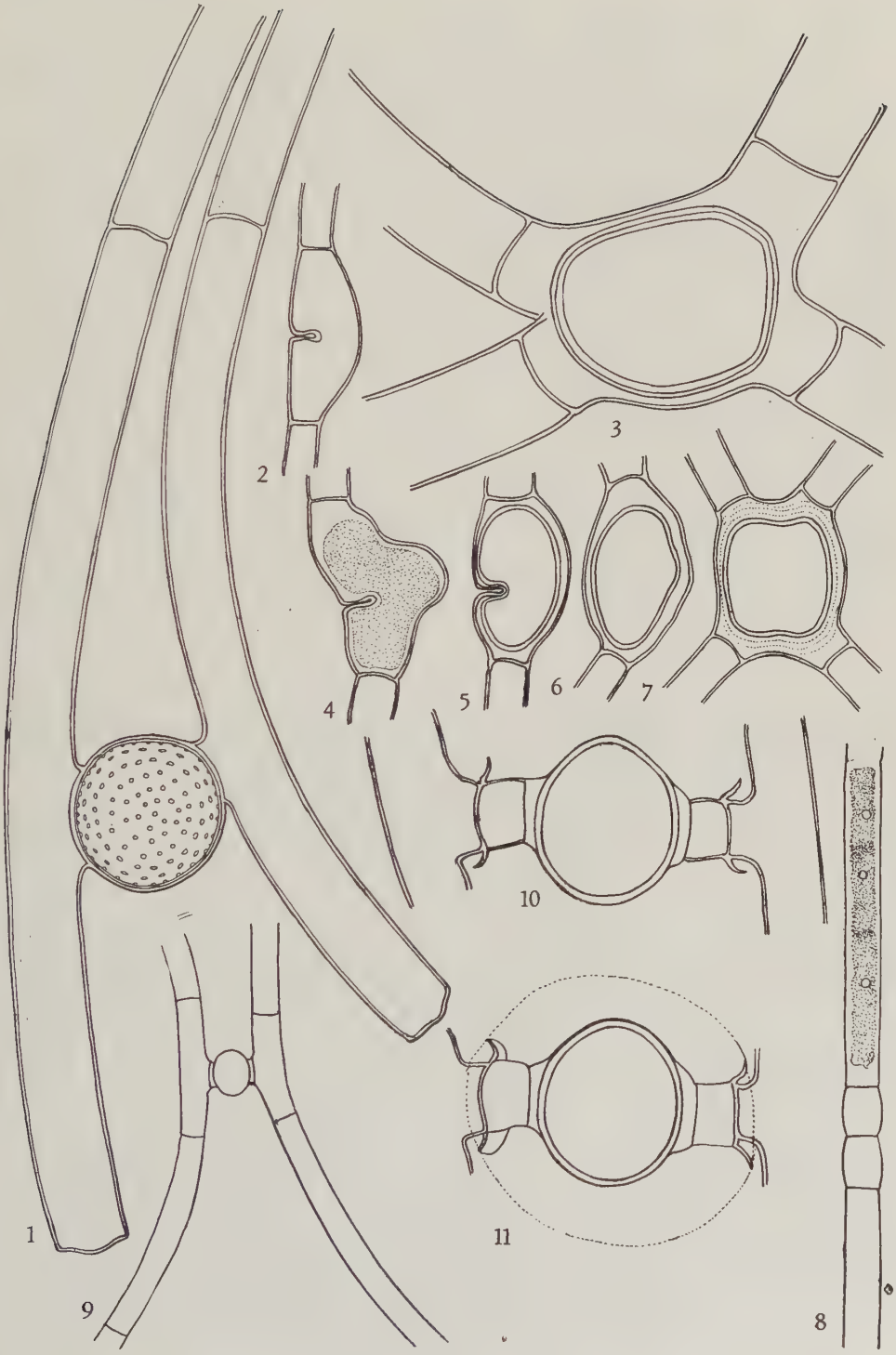
Vegetative cells 12–16 μ x 200–240 μ; chromatophore a narrow band with 4–6 pyrenoids in a row; conjugation scalariform by rather long tubes; zygospores compressed-globose, 26–28 μ x (30) 32–38 μ, outer wall bluish (by refraction), median wall thick, metallic green.

The sporangium wall is characterized by having an inner and outer layer of cellulose, separated by a thick pectic layer. As the spore reaches maturity the outer layer disintegrates equatorially and the pectic layer dissolves leaving a collar with recurved margins at the base of each half of the conjugation tube.

Cellulae vegetative 12–16 μ x 200–240 μ; chromatophorus taeniaformis, 4–6 pyrenoideis seriatis; conjugatio scalariformis tubis sublongis; zygosporae compresso-globosae, 26–28 μ x (30) 32–38 μ, membrana exterior (refractione) subcaerulea, membrana media crassa, metallice viridis.

Membrana sporangii proprie habet stratum cellulosum esterius interiusque per stratum pecticum crassum divisum. Ut spora maturescit stratlum exterius equatorialiter collabitur necnon stratum dissolvitur, collare marginibus recurvatis relinquens ad basim utriusque dimidii tubi conjugentis.

Ecuador: Volcano Cotopaxi; hanging bog at 14,000 ft.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Mougeotia cotopaxensis, sp. nov., Pl. I, Fig. 1.

Vegetative cells 10–15.5 μ x 80–250 μ, chromatophores with 2–4 pyrenoids in a row; conjugation scalariform; zygospores globose or compressed at right angles to the short conjugating tubes, 30–32 μ in diameter, median spore wall steel-blue, scrobiculate with pits about 1 μ in diameter, 4–5 μ apart, outer spore wall thin, smooth.

Cellulae vegetativae 10–15.5 μ x 80–250 μ; chormatophori 2–4 pyrenoideis seriatis praediti; conjugatio scalariformis, zygosporae globosae aut ad tubos breves conjugentes perpendiculariter compressae, 30–32 μ diam., sporae membrana media chalybea, scrobiculata, lacunis circa 1 μ diam., distantibus inter se 4–5 μ; sporae membrana exterior tenuis levisque.

Ecuador: Volcano Cotopaxi; hanging bog at 14,000 ft.

Temnogametum transeaui, sp. nov., Pl. I, Figs. 2–8.

Vegetative cells 14–20 μ x 100–400 μ, with a narrow, axial chloroplast, pyrenoids 2–4 in a row; conjugation lateral and scalariform; gametangia 20–22 μ x 20–30 μ at the ends of vegetative cells; zygospores by lateral conjugation obliquely ovoid, 35–42 μ x 80–100 μ; zygospores by scalariform conjugation 40–50 μ x 45–60 μ, median spore wall smooth, pinkish-buff to orange-brown at maturity.

Cellulae vegetativae 14–20 μ x 100–400 μ, chloroplastus axialis, angustus, pyrenoideis 2–4 seriatis; conjugatio lateralis scalariformisque; gametangia 20–22 μ x 20–30 μ in extremis cellulis vegetativis; zygosporae conjugatione laterali oblique ovatae, 35–42 μ x 80–100 μ; zygosporae conjugatione scalariformi 40–50 μ x 45–60 μ; sporae membrana media levis, puniceo-lutea ad flavo-brunneam cum maturuerunt.

Ecuador: Volcano Cotopaxi; hanging bog at 14,000 ft.

ON THE POSSIBILITY OF PRODUCING AN INTERPRETABLE VISUAL IMAGINE ON THE RETINA OF THE DIOPTRICALLY BLIND BY MEANS OF ELECTRIC PHOSPHENES

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When the retina is mechanically stimulated as by the pressure of the finger inserted between the bulb and the rim of the orbit, a sensation of light is produced in the opposite quadrant of the visual field. Such mechanically produced phosphenes have been known and remarked upon for centuries and the phenomenon has been used as evidence for the "projective" nature of vision. Likewise the adequacy of a mechanical or electrical stimulus in the elicitation of a visual sensation has been adduced as proof of the specificity of sensory end-organs.

Since the initiation of a visual sensation by other than an appropriate radiant energy stimulus is a property of the percepient elements of the eye, a study was undertaken to determine the feasibility of adapting the phosphene phenomenon to the production of visual sensations in cases where dioptric medium blindness existed. In these cases the percepient and interpretive elements (retina, optic nerves and tracts and occipital cortex) are intact; vision being hampered by the interposition of a mechanical barrier to the rays of light destined for the retina. Blindness due solely to lenticular, corneal and/or vitreous opacity is never complete, some degree of light perception and projection being maintained. Never-

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theless such cases make up the larger percentage of the blind and while theoretically this group is amenable to corrective surgery, the latter is not always practical. One hesitates, for instance in a case of complicated cataract to intervene surgically for fear of losing for the patient that modicum of vision, light perception and projection, which saves the patient from absolute blindness.

Since the retina may be intact, its utilization for the synthesis of useful visual images in dioptrically blind subjects, is a tantalizing prospect. The recent advances in television engineering might make it possible to correlate such images synchronously with visible transpirations in the external world.

With this object in mind, experiments were begun early in 1942, in anticipation of a large increment in corneal blindness cases that fortunately did not materialize—to lay a groundwork for adaptation of electrical phosphenes to synthetic images. So far this work has had a purely preliminary character. But the information elicited indicates that the construction of a mosaic phosphene "half-tone" by electrical stimulation of the retina, through the intact coats of the eyeball, is possible.

Stimulation of a single rod or cone would produce an image subtending about 60 seconds of visual arc. It was desired to determine how close an approach could be made, by non-visual stimulation through the intact sclera, to this theoretically minimum limit. Normal human subjects who had the lid reflex of one of the eyes abolished by the conjunctival instillation of 2% butyn and whose other eye was covered by a patch, were instructed to rotate the anesthetized eyeball maximally upward and to maintain it in this position while mechanical stimuli were applied as far back as possible in the conjunctival fornix by means of a No. 32 gauge phosphor bronze wire. In this manner it was possible to produce phosphenes close to the foveal area. Such phosphenes were recorded as to position and subjective size, the latter being estimated by subsequent comparison with a set of perimetry targets.

Though only an approximate indication could thus be gained of the possible size of mechanically induced phosphenes, it was evident that all subjects could identify and project those of 2° and over. Separate phosphenes could be produced and spacially projected when the separation of 5° or more was made between the applied wires.

Increasing the pressure upon the applied wire increases the size of the produced phosphene; this seems to be due exclusively to the increase in the size of the scleral distortion cone produced by such pressure. There is no irradiation of image size with mechanical pressure in any form. The situation was different when electrical stimulation was applied through the apposed wire. Using a single negative galvanic stimulus of 5 milliamperes, the resulting phosphene approximated that produced by mechanical pressure. With faradic stimulation, the size of the phosphene increased with the duration of the stimulus; where the latter was for more than a second, there was an irradiation effect resulting in a phosphene that occupied an entire quadrant of the visual field.

Since the phosphene size is apparently a combined function of the area and duration of the stimulus, the latter could be modulated to produce an actual complex mosaic image. In discussing this matter with Dr. William Edson of the Communications Engineering Department of Georgia Technologic Institute, he has stated that the stage of the television art should render it feasible to form such patterns on the retinae of the dioptrically blind by electronic devices. He suggested in this connection a scanning device which would consist of a multi-wired cable, originating in a televisor, the distal end of which would be molded so as to approximate the curvature of the sclera; that the elements of the cable in contact with the sclera would each furnish a regional stimulation in the proper time, sequence and space relationships to coincide with the external picture and to reduplicate the latter as a rough mosaic in the visual field.

A LIST OF THE STONEFLIES, PLECOPTERA, KNOWN TO OCCUR IN SOUTHEASTERN OHIO[1]

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During 1939–1941 collections of stoneflies were made from most of the larger streams and many of the smaller ones in non-glaciated Southeastern Ohio. Athens County was covered very thoroughly and as many trips as possible were made into neighboring counties. The main stream of the Hocking River and some of its smaller branches, Federal Creek, Queer Creek and Salt Creek yielded considerable numbers of specimens. Sunday Creek, Monday Creek and Raccoon Creek were relatively without stonefly populations.

Many specimens in the Ohio University Collection were made available to the author by Dr. Wm. C. Stehr, who also gave many suggestions in the conduct of the survey and generously helped with the problem of transportation. The late Dr. T. H. Frison of the Illinois Natural History Survey kindly checked all determinations. To both of these men the author expresses his appreciation.

Altogether twenty-four species of stoneflies were collected during the survey. A few additional records of the same species and five species not taken during the study were found reported for Ohio in published works on the stoneflies of North America. These have been added to our list and acknowledgment is there made of the source of the data. A few of these are from the glaciated section of Ohio and it is likely that a survey of that portion of the state will yield some additional species for Ohio.

Distribution is given by counties. The names of collectors follow the county records. Since the most of the records are from collections by Wm. C. Stehr and John D. Walker, their records are designated by the letters *S* and *W* respectively. Most of the specimens on which these records are based are either in the collection of Ohio University or the Illinois Natural History Survey. Some of those recorded by Frison and those recorded by Claassen are probably in other collections.

LIST OF PLECOPTERA KNOWN FROM SOUTHEASTERN OHIO

1. *Taeniopteryx fasciata* (Burm.)
   Athens: S
2. *T. maura* (Pictet)
   Athens: S, W, Harold W. Smith
3. *Nemoura divergens* Clsn.
   Athens: S, W
4. *N. venosa* Banks
   Athens: S, W; Tuscararawas: W; Hocking: W; Vinton: W; Washington: S
5. *Leuctra claasseni* Frison
   Athens: S, W; Hocking: W
6. *L. decepta* Clsn.
   Hocking: W
7. *Capnia opis* Newman
   Franklin: L. S. Roach; Hocking: J. N. Knull. These records are given by Frison.

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[1]Paper No. 31 from the Department of Zoology, Ohio University, Athens, Ohio.

8. *Allocapnia forbesi* (Frison)
   Athens: S, W
9. *A. pygmaea* (Burm.)
   Athens: S, W, Frison; Hocking: Frison
10. *A. vivipara* (Clsn.)
    Athens: S, W
11. *A. rickeri* Frison
    Athens: Frison; Muskingum: Ross. These are recorded by Frison.
12. *A.* near *granulata* (Clsn.)
    Athens: S
13. *Acroneuria abnormis* (Newman)
    Athens: S, W; Washington: L. P. Reynolds
14. *A. xanthenes* (Newman)
    Athens: S, W
15. *A. perplexa* (Frison)
    Athens: S, W, W. P. Porter
16. *A. arida* (Hagen)
    Athens: S; Holmes: R. P. Thomas; Ottawa: P. S. Shurrager
17. *A. filicis* Frison
    Athens: S. This is a paratype series.
18. *A. evoluta* Klap.
    Athens: John C. Herron; Ottawa: Clark; Preble: T. Snyder
19. *A. mela* Frison
    Athens: John C. Herron; Adams: J. S. Hine. The latter is recorded by Frison.
20. *A. lycorias* (Newman)
    Recorded from Ohio specimens in the Illinois Natural History Survey Collection by Frison. The species was taken by Stehr in Carter County, Ky., and so is likely to occur in Southeastern Ohio.
21. *Perlesta placida* (Hagen)
    Athens: S; Holmes: R. P. Thomas; Lucas: S
22. *Hastoperla brevis* (Banks)
    Athens: W; Hocking: J. N. Knull. The latter is recorded by Frison.
23. *Isoperla bilineata* (Say)
    Athens: S; Hocking: W; Tuscarawas: W
24. *I. confusa* Frison
    Athens: S, W; Tuscarawas: W
25. *I. duplicata* (Banks)
    Athens: S, W; Vinton: W; Hocking: W; Tuscarawas: W
    This is by far the commonest species of stonefly in Southeastern Ohio. Nearly as many specimens of it were taken as of all others combined.
26. *I. minuta* (Banks)
    Franklin: Recorded from Columbus by Claassen.
27. *Alloperla mediana* Banks
    Athens: W
28. *A. imbecilla* (Say)
    Hamilton: Recorded from Cincinnati by Claassen.
29. *Neoperla clymene* (Newman)
    Athens: S; Ottawa: P. S. Shurrager

SUPPLEMENTARY RECORDS

Mr. Lee Stewart Roach of the Ohio Division of Conservation has kindly furnished the following stonefly records from Black Lick, Franklin County, Ohio. These specimens were also determined to species by the late Dr. T. H. Frison.

This list adds two species to our state records, namely *Capnia vernalis* (Newport) and *Neophasganophora capitata* (Pictet). Of the latter Walker had taken three naiads in Athens County that were questionably so determined by Frison and hence were not included in the foregoing section of this paper.

RECORDS FROM BLACK LICK, FRANKLIN COUNTY, OHIO: L. S. ROACH

Taeniopteryx maura (Pictet) (*nivalis* Fitch)
Capnia vernalis (Newport)
Allocapnia vivipara (Claassen)
Acroneuria arida (Hagen)
evoluta Klap.
Neophasganophora capitata (Pictet)
Perlesta placida (Hagen)
Isoperla confusa Frison
Neoperla clymene (Newman)

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